The American Journal of Surgery

EDITED BY THURSTON SCOTT WELTON, M.D.

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FIFTY-SIXTH YEAR OF CONTINUOUS PUBLICATION

April 1947

VOLUME LXXIII NUMBER 4

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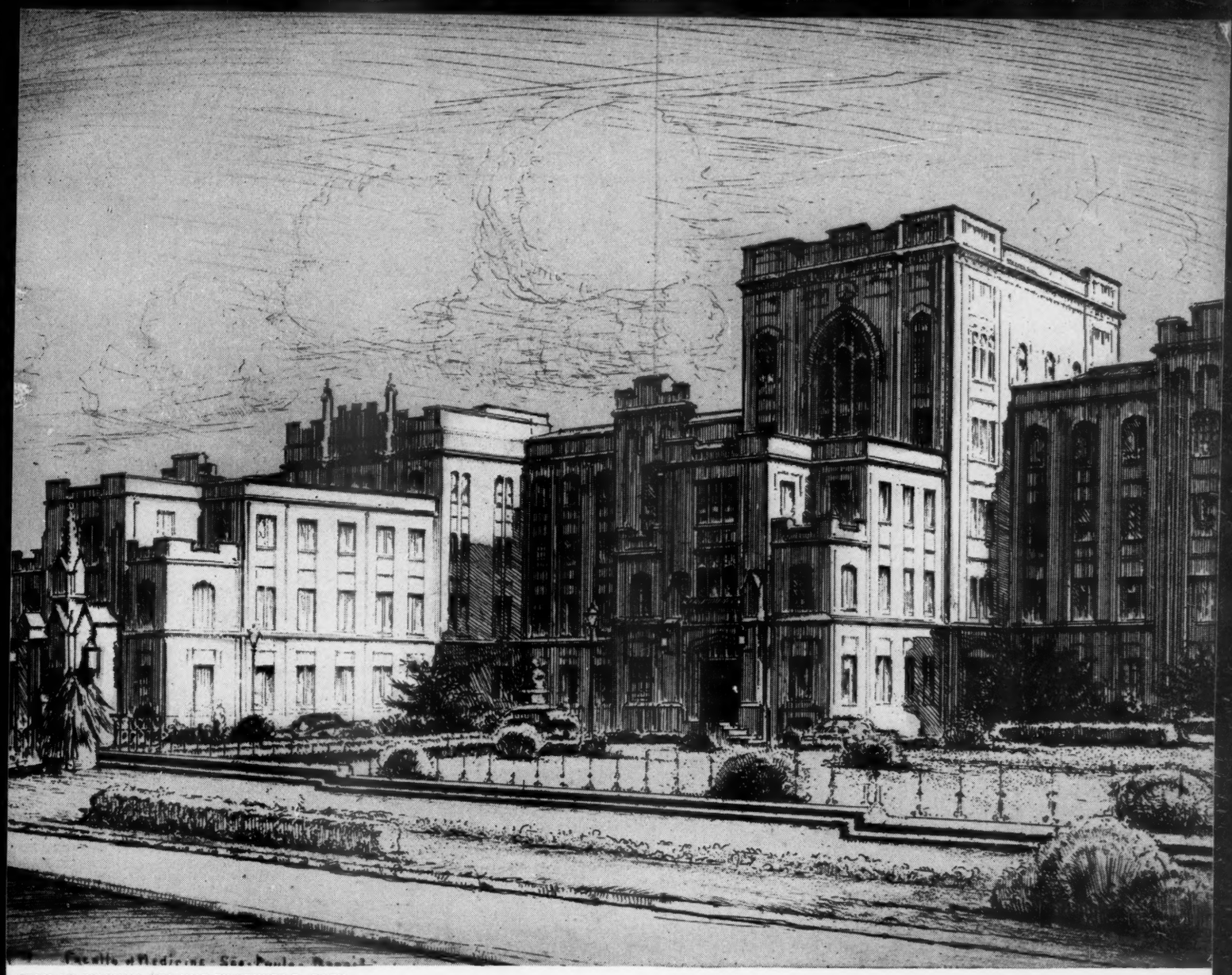


FROM AN ORIGINAL ETCHING BY ERNEST D. ROTH

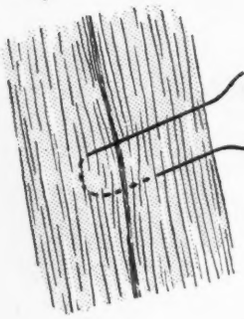
FACULDADE DE MEDICINA E CIRURGIA, SAO PAULO, BRAZIL. Created by the São Paulo State Law of 1891, the Faculty of Medicine and Surgery of São Paulo is one of the foremost institutions for the study and teaching of the medical sciences in South America. The splendid record of the public health services and agencies in southern Brazil is due in no small part to the efforts of those physicians and surgeons whose training was received at the Faculty of Medicine in São Paulo.

Training and education, continuing throughout a career, lead to the successful and constructive practice of medicine and surgery. Similarly, Davis & Geck progresses in knowledge of the needs of advancing surgical techniques, thereby providing surgeons with sutures of outstanding quality and selective range to meet every requirement.

SUTUREGRAM

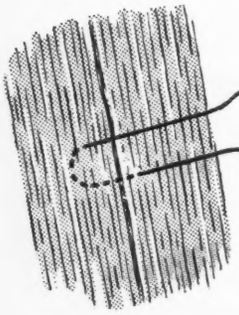
NUMBER ONE IN A SERIES

Capacity of tissues to hold sutures

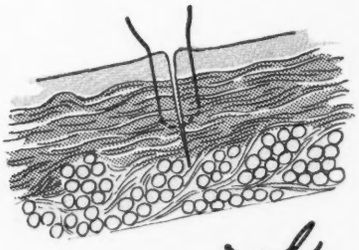


An untied suture pulls out of Muscle at ¼ lb...

...fat at ⅛ lb...



...fascia at 8 lbs...



...skin at 10 lbs...

Hence if a strong wound is desired, Fascia, the connective tissues and skin should be sutured. Sutures in Fat and Muscle do not contribute strength to the wound. Muscle and Fat should be approximated by suturing their surrounding fascia or connective tissue septae.

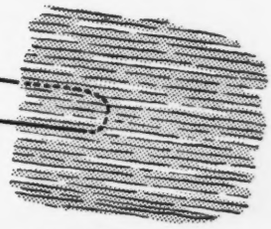
SUTUREGRAM

NUMBER ONE IN A SERIES

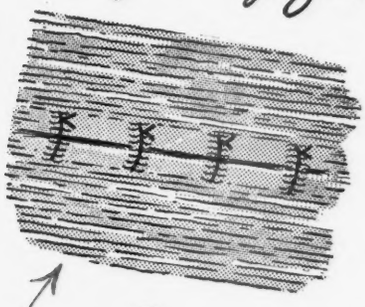
Capacity of tissues to hold sutures

An untied suture pulls out of fascia at 8 lbs against the fibers of fascia

at ½ lb with the fibers



Consequently the wound is strongest when sutures are placed so they must pull against the fibers of fascias. This is done in 2 ways...

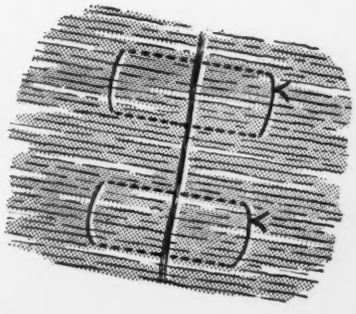


① Wound is made parallel to the fibers of the fascias

or

② If wound divides fibers mattress sutures are used Part of this suture pulls against the fibers

Best



A new series
of graphic messages on
suture techniques
and the complications
of suturing called

Sutureograms

begins on inside pages
of this insert

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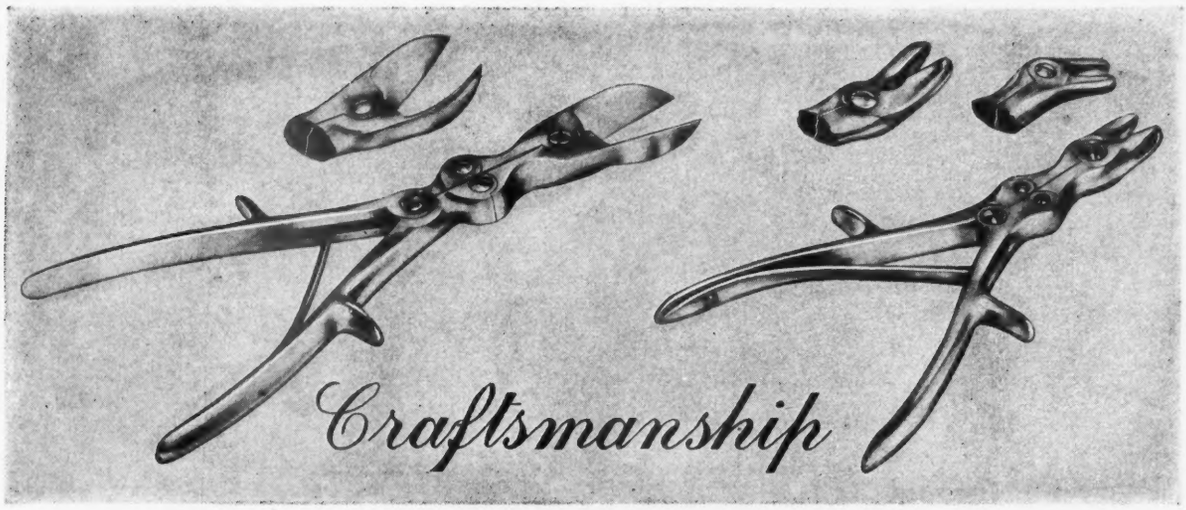

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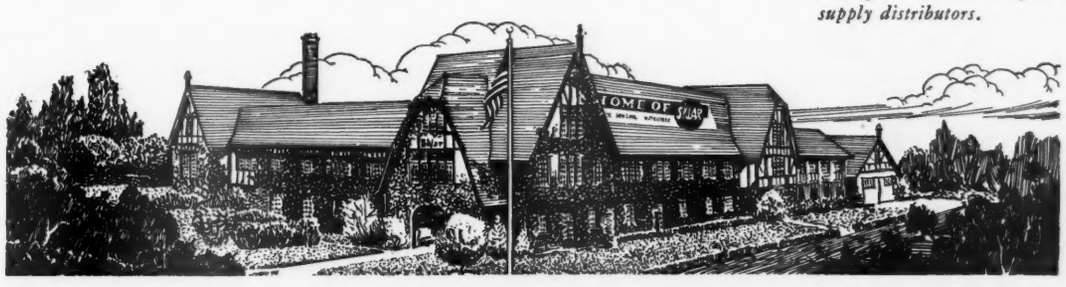

Major advance in absorption control

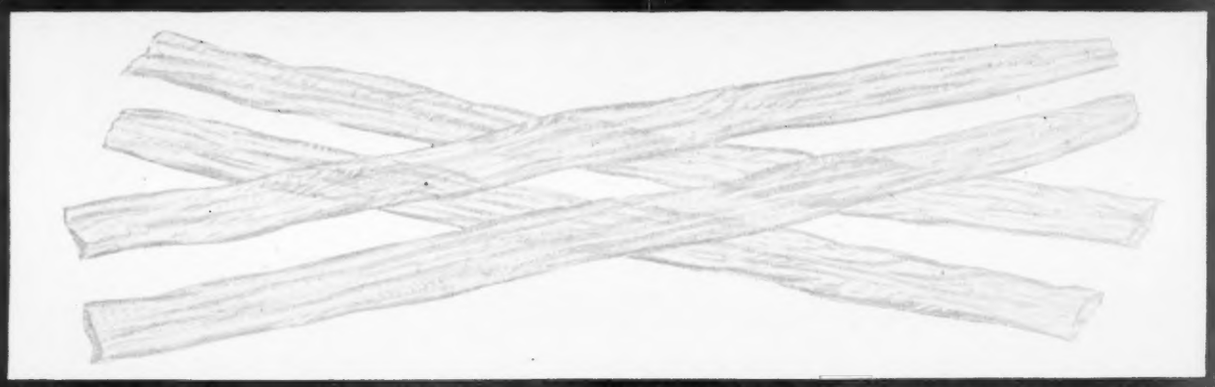

Fig. 1—Catgut ribbons, or plies, which form a strand of Curity Catgut. Plies *in raw state* have a glutinous exudate, *natural mucin.*

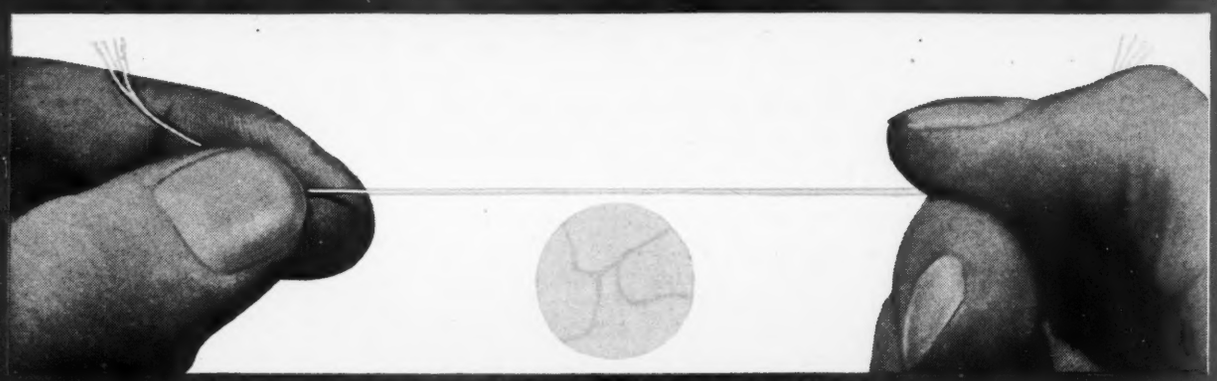

Fig. 2—Plies twisted into raw gut strand. The mucin acts as a *natural* bonding agent, holding plies firmly together. No foreign adhesive agent is added. Chromicization will strengthen the bond by *fixing* the mucin. Cross section (insert) shows twisted plies in finished strand.

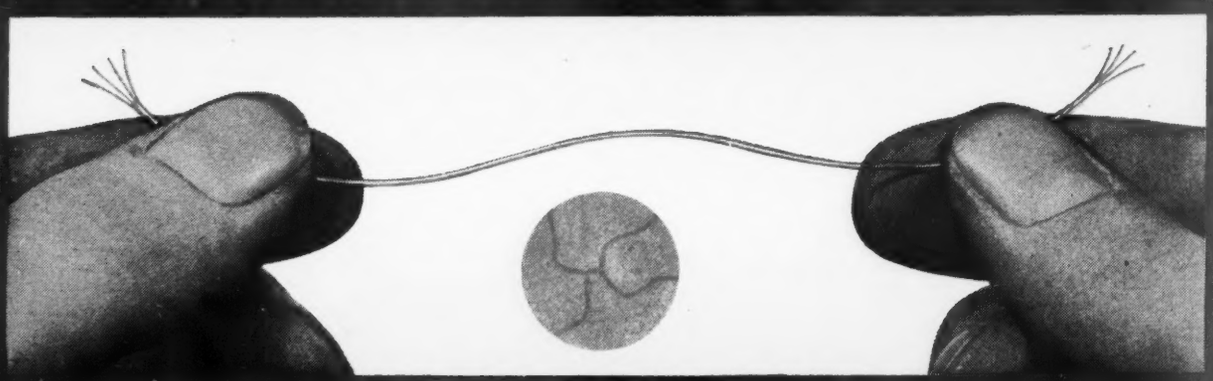

Fig. 3—Finished strand of Curity Catgut, chromicized by the new Curity process. Note characteristic natural olive green color of strand. Cross section (insert) shows even distribution of chrome salts from rim to center—*total* chromicization. Yet *natural* ply adhesion, due to mucin, has been fully preserved.

Color and specifications indicated above are used solely for graphic representation.

SUTURE RESEARCH . . . TO ESTABLISH A FINE BALANCE OF NECESSARY CHARACTERISTICS

further improves Curity Catgut

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New process effects total chromicization without sacrifice of natural ply adhesion

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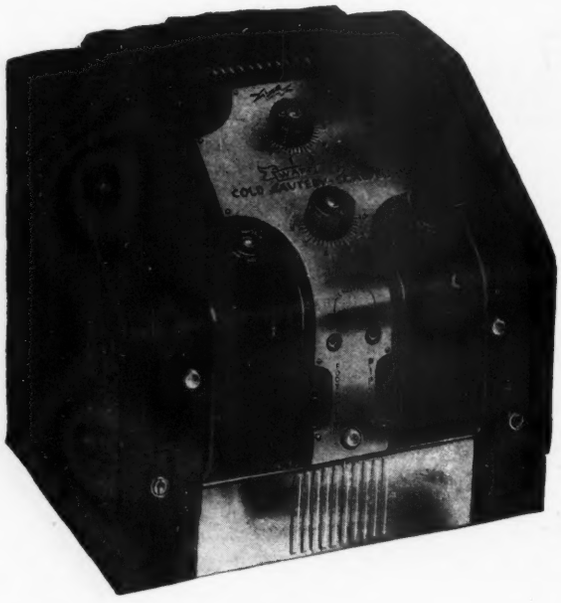

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which completely describes various sets of electrodes and accessory instruments.

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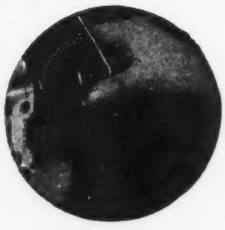
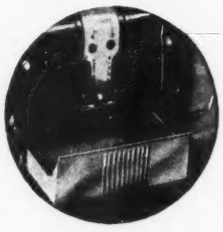
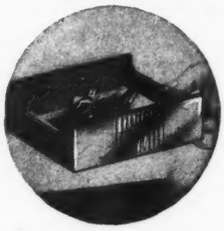


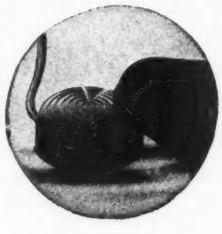
Conducting cords leading to the active and indifferent electrodes are housed within the case. To return the cords to their original position, pressure on the button above them instantly rewinds the cord.



The drawer and contents are automatically ejected from the case upon pressure on a button located directly above the drawer.



The cord connector of the shock-proof footswitch is plugged into the outlet marked "Footswitch." Bipolar electrodes, handle and cord are plugged into the receptacle marked "Bipolar."



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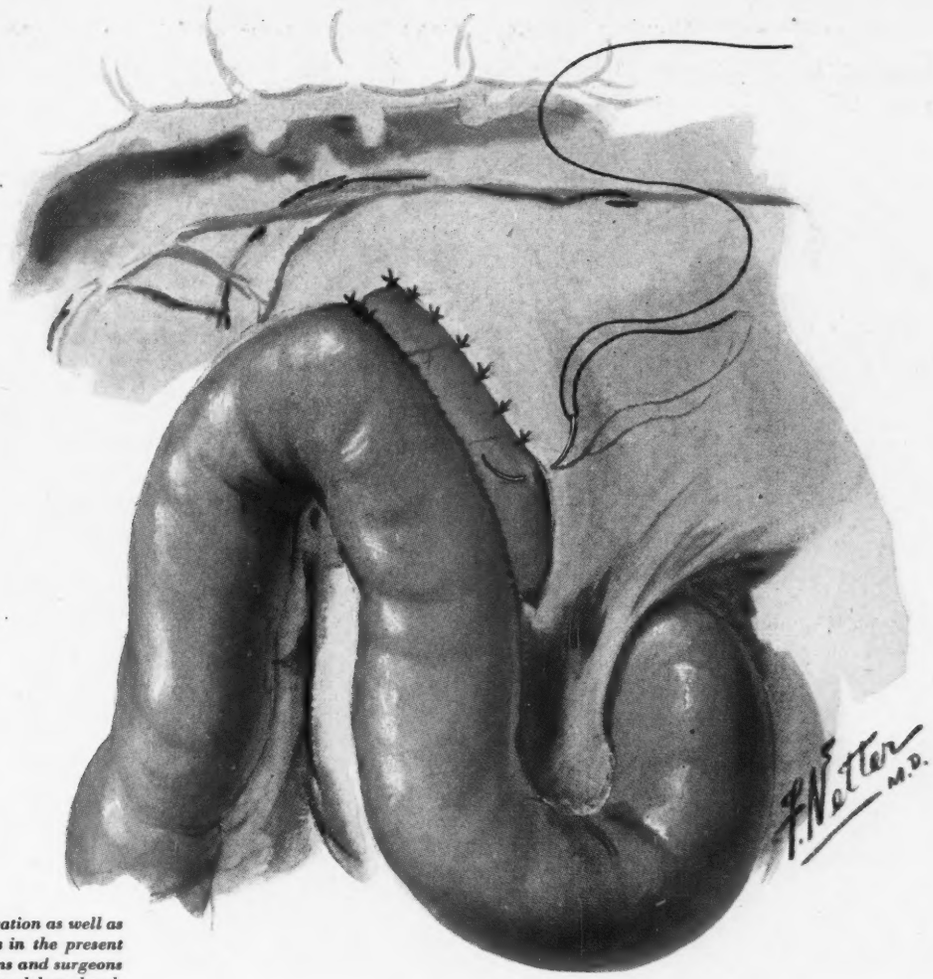

A copy of this illustrated operation as well as the other surgical illustrations in the present series will be sent to physicians and surgeons when requested on a professional letterhead.

Posterior (Retrocolic) Gastro-Jejunostomy (Continued)

The first half of the operation of posterior gastro-jejunostomy has been illustrated in a previous issue. The remainder of the operation is pictured on the following pages. This is, of course, a one-stage operation but because of the number of illustrations required for detailed portrayal, it has been presented in two parts.

In gastric operations as in other fields of surgery, the quality of the suture material employed is important, not only for safeguarding the suture line, but because the good "working properties" of a suture may facilitate the operation. ARMOUR SURGICAL GUT has earned a reputation for flexibility, pliability, and nice tying qualities as well as for its tensile strength, uniformity and general reliability. Good surgery demands the best in sutures and ligatures—specify ARMOUR.

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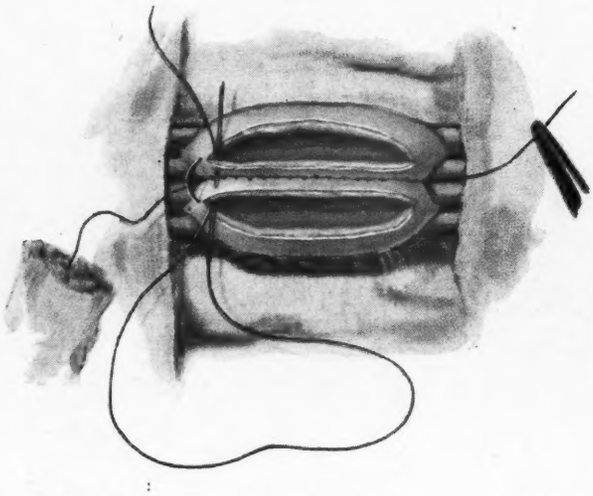
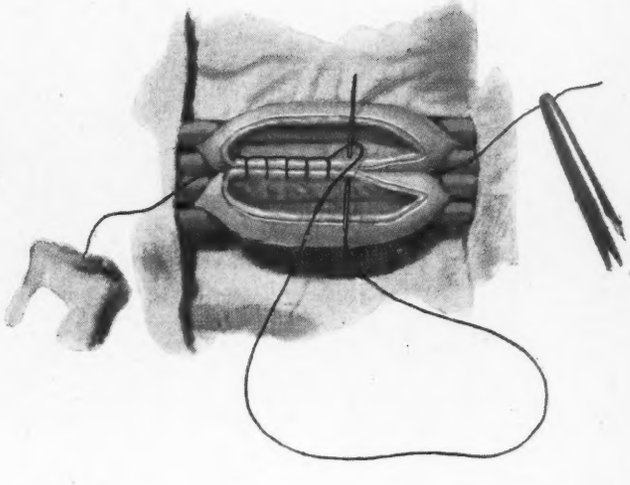
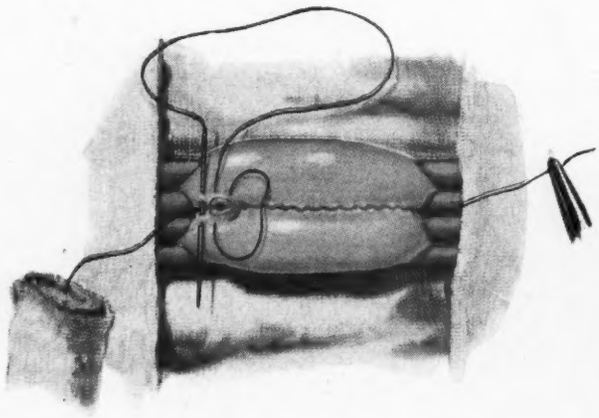


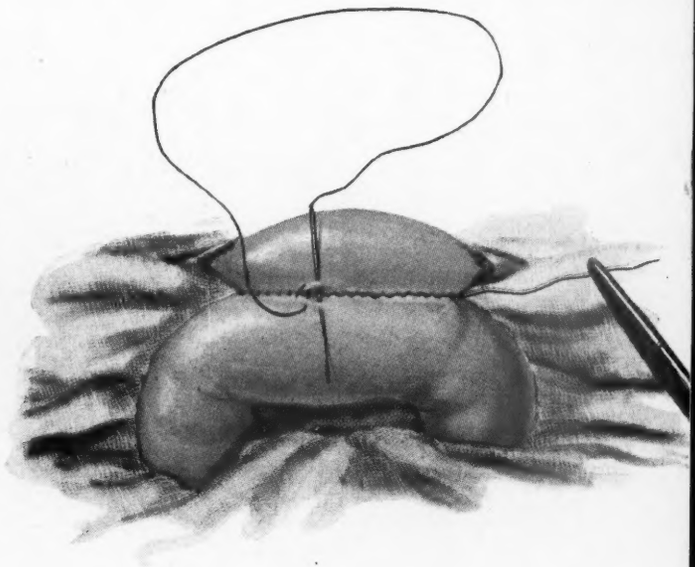
IX. Beginning second suture line; stitch applied to effectively close the angle.



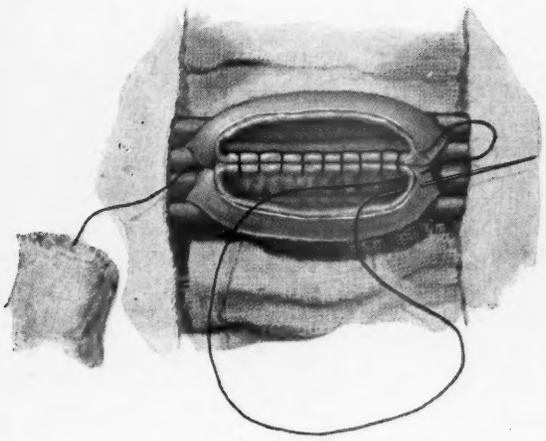
X. Continuous posterior wall lock-stitch.



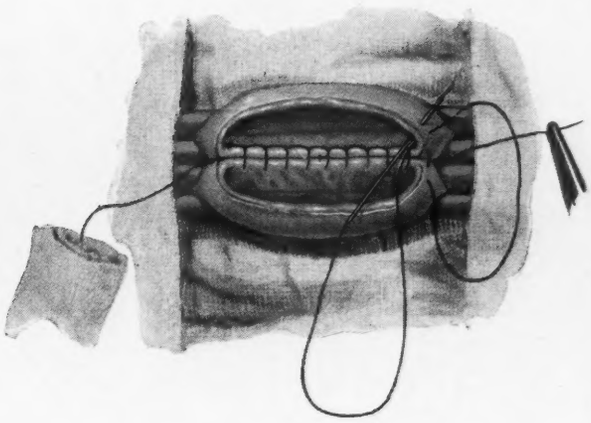
XIII. Completion of anterior wall closure.



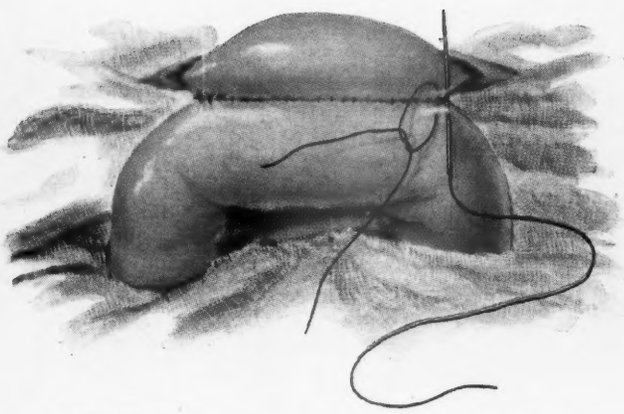
XIV. Rubber-covered clamps removed. Lembert sero-muscular suture now continued on anterior wall.



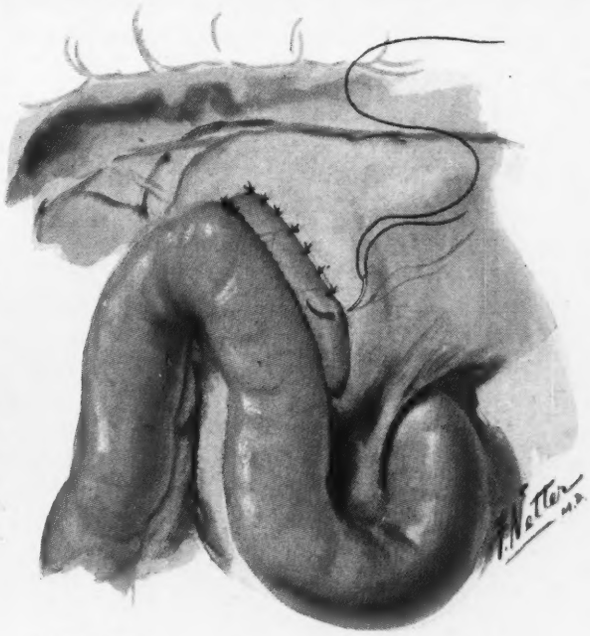
XI. Suture brought outside lumen preparatory to starting the anterior wall inverting Connell suture.



XII. Start of Connell suture closing the anterior wall of the anastomosis.



XV. One or two additional sero-muscular sutures placed to reinforce both angles of anastomosis.



XVI. Wall of stomach sutured to left margin of opening in the transverse mesocolon.

Armour Sutures and Ligatures

Scrub Up!

In the "scrubbing up" operation, the surgeon often is unaware of the difficulties which may confront him later. What seems beforehand like a relatively simple procedure may, at the operating table, develop into an extremely difficult operation calling for the utmost skill, knowledge and courage. It is of vital importance therefore in performing surgery of any type, that the suture and ligature materials employed be of the very finest quality — thus eliminating any unnecessary burden on the operator.

ARMOUR SUTURES and LIGATURES have an outstanding reputation for excellence — and with good reason. Armour has available the world's largest supply of animal raw material from which to select the best. Armour has the "know-how" for turning it into superior surgical gut. Armour surgical gut fulfills all requirements for tensile strength, uniformity and sterility, but it has something more — workability. Armour surgical gut has just the right flexibility and pliability. It yields readily to the surgeon's skilled hands. It ties down firmly and securely into tight knots. These are the essentials of good sutures and account for many surgeons preferring Armour suture and ligature materials.

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THE *Armour* LABORATORIES

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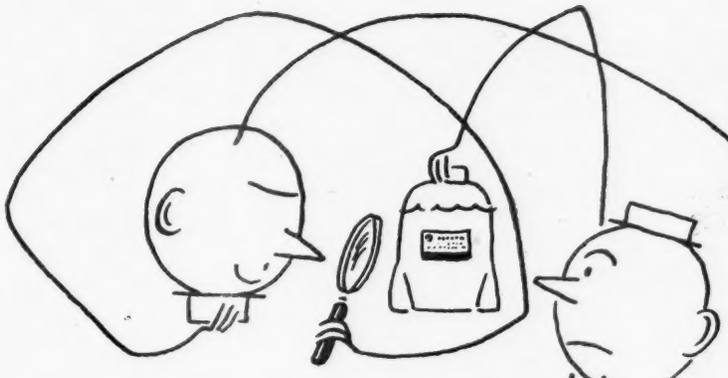
GOOD SURGERY DEMANDS THE BEST IN SUTURES AND LIGATURES



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Just to prove SAFTIFLASK SOLUTIONS safe!

Take it from us! Pyrogens in Saftiflask Solutions don't stand the chance of a snowball in—well—when the Cutter testing staff gets rolling.

They've rigged up every conceivable test to rule out solutions that could cause reactions. Tests for aerobic and anaerobic contamination—for molds—for chemical identity and purity. Then they shoot 'em into rabbits, to make sure every batch is reaction-free.

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Add to such safety the *convenience* of Saftiflask technic—and you have the ideal I. V. setup for your hospital. Assembled complete, Saftiflasks require only injection tubing to be ready for smooth, trouble-free administration. But see Saftiflasks in action to prove it to yourself. Your Cutter representative will be glad to demonstrate.

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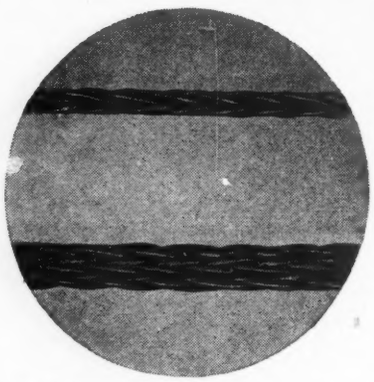
BRAIDED TANTALUM

A USEFUL, NEW SUTURE MATERIAL



Many individual strands of wire are in Ethicon Braided Tantalum. Photomicrograph, above, shows Sizes 3-0 and 1, magnified to x15.

ETHICON TANTALUM FOR SURGICAL USE

Sutures. Monofilament: Sizes 6-0, 5-0, 4-0. Swaged to Eyeless Atraloc needles. *Braided:* As described at right.

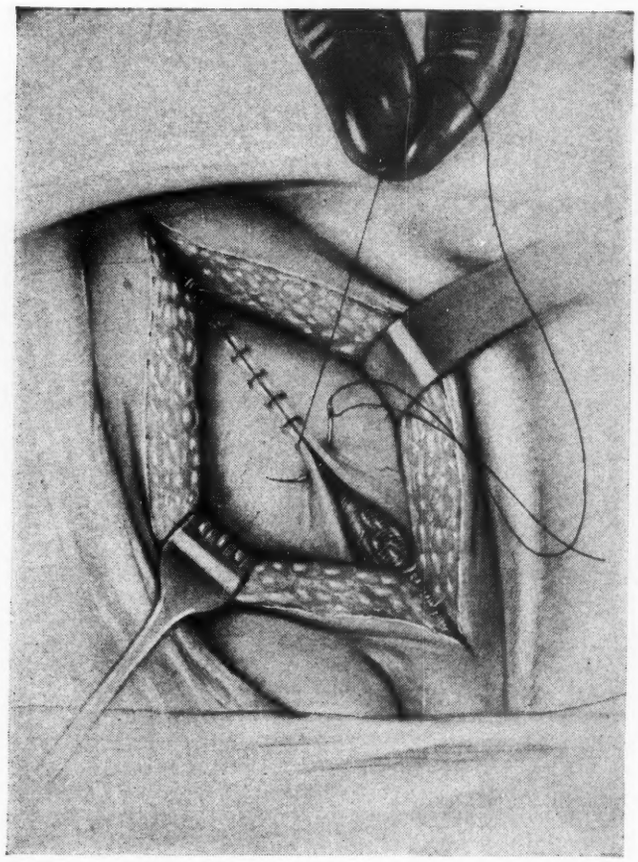
Wire. Suturing material on spools. Sizes 6-0, 5-0, 4-0, 000, 0, 2, 4.

Ribbon. For making neurosurgical hemostasis clips. Clips also supplied ready-made.

Sheet. For skull plates in cranioplasty and general plastic surgery.

Foil. Used in neuro- and orthopedic surgery for protection of nerves and tendons.

Literature describing use of Ethicon Tantalum products available on request.



• Braided tantalum is a new Ethicon suture material which offers the surgeon certain qualities not found in other sutures.

1. Its "handling properties" are superior to monofilament wire. It is much stronger than silk and less variable in size.
2. Its tensile strength is not affected in the presence of infection.
3. When Braided Tantalum is used as a buried suture, the attachment of the tissues to the suture aids greater anchorage.

Ethicon Braided Tantalum Sutures are supplied in Sizes 5-0 to 1, in 60 inch length on card reels.

Braided Tantalum has been found of special value for general surgical closure, plastic surgery, the Guyton operation for ptosis of eyelid and herniorrhaphy.

ETHICON

Sutures

FOR EVERY SURGICAL PURPOSE

ETHICON SUTURE LABORATORIES

Division of Johnson & Johnson, New Brunswick, N. J.

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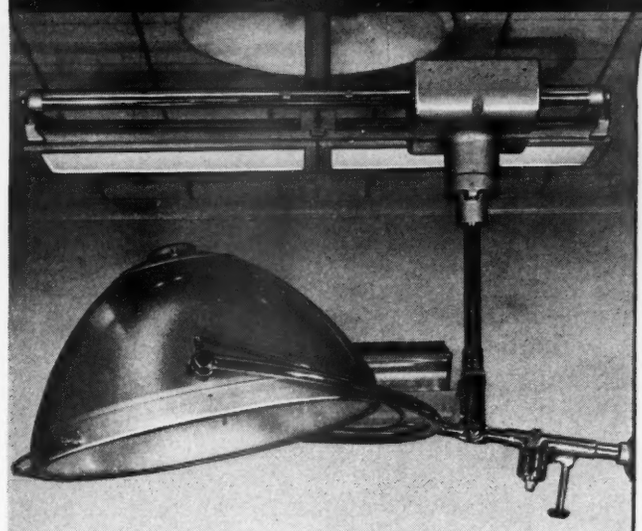

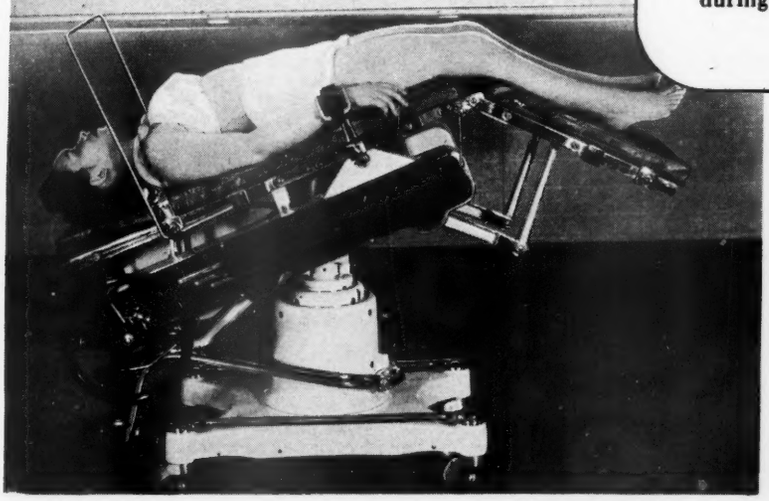

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affords these two outstanding advantages—

First– **The positioning of the patient in an infinite number of different surgical postures while safely immobilized under the anesthetic.**

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Note—The surgical light, illustrated, is another American product of superior design and quality.

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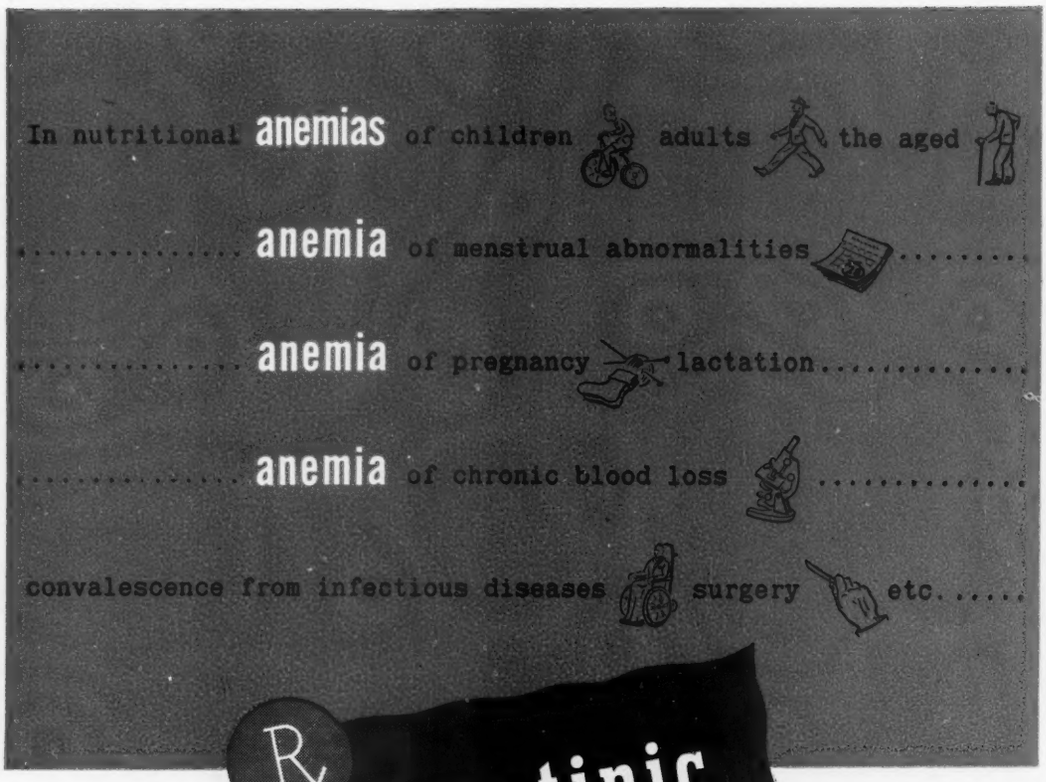
In nutritional anemias of children adults the aged
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anemia of pregnancy lactation
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(McNeil)

—most readily assimilable form of iron (ferrous sulfate) combined with a unique, high-potency, predigested form of crude (unfractionated) liver concentrate—plus the factors of the vitamin B Complex—

—a hematinic agent and nutritional supplement, which your patients —young, old or middle-aged—will take and continue taking—

—has a delightful flavor—and the dosage is small: one teaspoonful t.i.d. Supplied in bottles of 8 fl. oz. and 1 pint.

The alcoholic content of Hepatinic is very low—making it safe for pediatric use. Tasting samples available on request.

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• Each fluidounce contains: Ferrous sulfate 12 gr., Crude Liver Concentrate 60 gr., fortified to represent Thiamine Hydrochloride 2 mg., Riboflavin 4 mg., Niacinamide 20 mg., together with pyridoxine, pantothenic acid, choline, folic acid, vitamin B_{10}, vitamin B_{11}, biotin, inositol, para-aminobenzoic acid and other factors of the vitamin B complex as found in crude (unfractionated) liver concentrate.

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the answer is **GUDEBROD**

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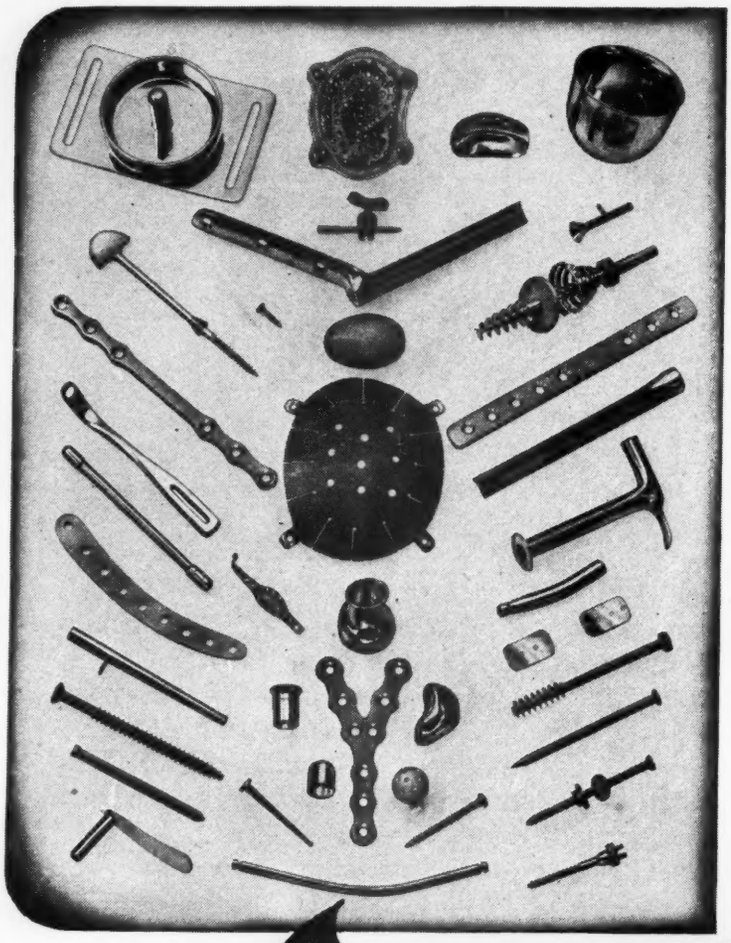

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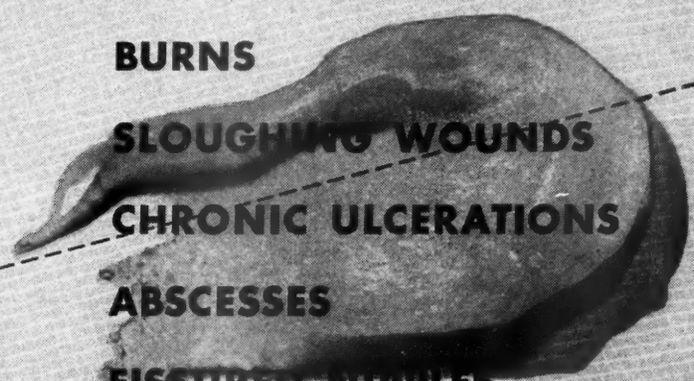
speeds healing process in AVULSIVE INJURIES



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Mounting clinical evidence emphasizes the value of topically applied vitamins A and D in the repair and regeneration of all healing surface lesions involving epithelial denudation.

Therapeutic advantages: promotes healthy granulation and rapid epithelization, inhibits infection, minimizes skin grafting, destroys no epithelial elements, does not cause contractures, forms no tenacious coagulum.

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Available in ½ oz. tubes; 8 oz. and 16 oz. jars and 5 lb. containers.

*Brougher, J. C.: West. J. Surg., Obst. and Gyn. 52:520, 1944.
Weissburg, R. S.: Soviet Med. 4:28, 1940.

Vitamin A D *and*

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Among the Milestones of Medical Advancement

The recognition that protein nutrition must be maintained in the presence of many pathologic conditions or states in which not so many years ago it was thought to be necessary to curtail the protein intake, may well be considered one of the milestones of medical advancement. In fact, today protein is recognized as one of the most important factors in the management of these very conditions.

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Presurgically as well as postsurgically a diet rich in protein of high biologic value reduces the hazards of surgery and hastens wound healing and general recovery.

Among man's protein foods meat ranks high: (1) because its protein is of excellent biologic quality, providing all the important amino acids; (2) because of the percentage of protein contained; (3) because of its outstanding digestibility.

The Seal of Acceptance denotes that the nutritional statements made in this advertisement are acceptable to the Council on Foods and Nutrition of the American Medical Association.

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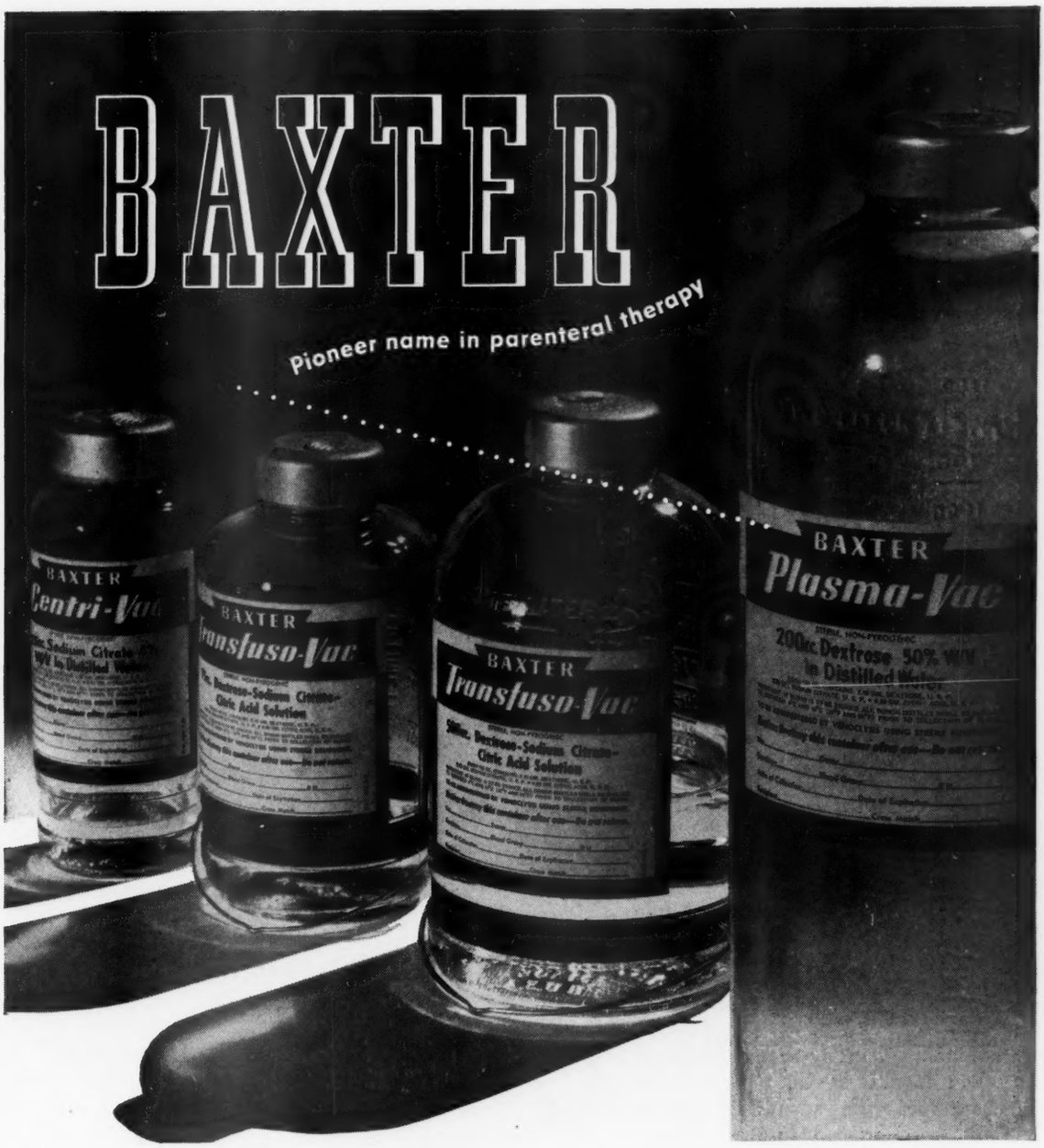

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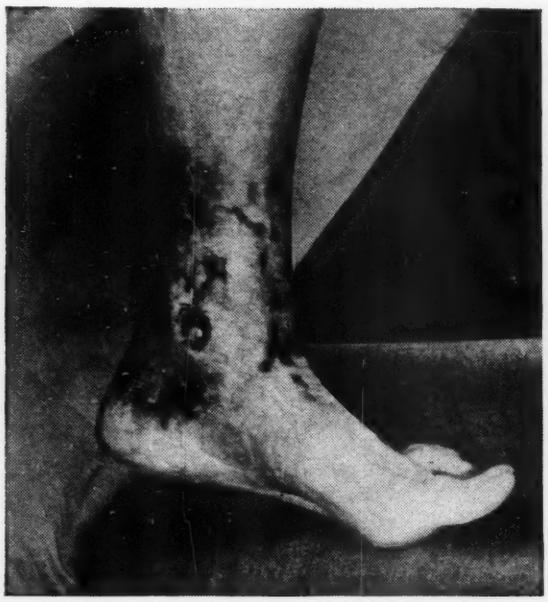

Painful Ulcer which had developed spontaneously following a "milk leg" during pregnancy some 34 years before. This ulcer had been treated many times in various ways, but had never once healed.

Treated with Chloresium and penicillin dressings almost daily. Pain was promptly diminished; rapid filling in and closure noted. Patient completely healed 18 days after treatment was begun.

For healing and deodorizing acute and chronic ulcers, wounds, burns and osteomyelitis—

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natural, nontoxic chlorophyll therapy

Leading clinics verify that chlorophyll therapy as made possible by Chloresium is remarkably effective in *healing* and *deodorizing* acute and chronic suppurative conditions. This is due to the action of the *water-soluble* Chlorophyll derivatives in Chloresium which stimulate normal cell growth, encourage epithelization and eliminate odors found in suppurative lesions.

From the Lahey Clinic Bulletin (Vol. 4, No. 8, April 1946): "(*Chloresium*) apparently excels any of the previously used agents for the local treatment of chronic ulcers of the leg . . . The absence of any local irritation or toxicity, the rapid appearance of healthy granulation tissue, and good epithelization were impressive."

From the Guthrie Clinic Bulletin (Vol. 16, No. 1, July 1946): "We have used a water-soluble ointment of chlorophyll (*Chloresium*) in a variety of conditions, particularly in burns, chronic ulcers and osteomyelitis, with splendid results in a vast majority of the cases."

Chloresium is ethically promoted. At leading druggists in 3 forms—Solution (Plain), Ointment and Nasal Solution.

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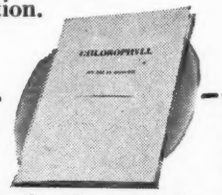

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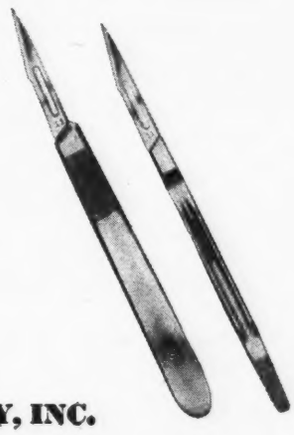

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BARD-PARKER COMPANY, INC.
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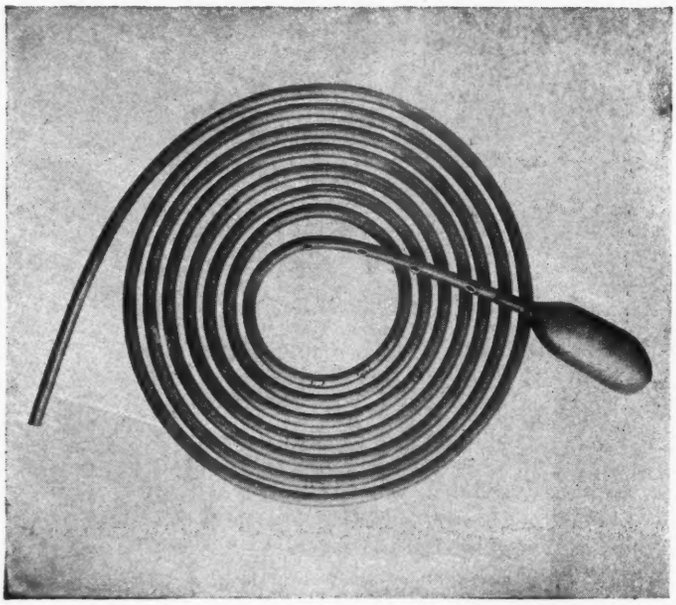
A BARD-PARKER PRODUCT

A *Simplified* tube for INTESTINAL INTUBATION



Described by Dr. Meyer O. Cantor, Detroit, American Journal of Surgery, July 1946; and in other articles soon to be published in the American Journal of Surgery.

The CANTOR TUBE

THE CANTOR TUBE is a latex bag-tipped, mercury weighted, single lumen tube. It is 18 Fr. and 10 feet long. Its movement down the alimentary tract is actuated by a combination of free-flowing qualities of the mercury and the peristaltic action on the bolus formed by the mercury in the bag. Mercury is given the maximum motility by the loose latex bag attached distal to the tube. It is the only tube utilizing all the physical properties of mercury.

Tubes are marked as follows to indicate their position: "S" for stomach at the 17″ mark, "P" for pylorus at the 24″ mark, "D" for duodenum at the 30″ mark, then in feet at the 4, 5, 6, 7, 8 and 9 feet marks.

Secondary dilatation of the stomach can be decompressed by withdrawing the tube a short distance, cutting holes into the tube, and allowing the tube to be pulled down by peristalsis at which point the holes will open to the stomach which, on applying suction, will be decompressed. Replacement latex bags are easily cemented to the tube.

Features . . .

1. *Greater ease of intubation*—first, ease of passage thru the nares and nasopharynx; and second, *ease of passage thru the pylorus.* Of 100 cases *96 %* were *successfully intubated.*
2. *More efficient decompression*—resulting from larger luminal diameter and *less possibility of plugging.*
3. Complete absence of any metal parts which might injure the mucosa.

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Only about 5% of the drug is absorbed. Activity is confined to the intestinal tract. Blood levels are low. Toxicity is negligible. • 'SULFASUXIDINE' *succinylsulfathiazole* is supplied in 0.5-Gm. tablets in bottles of 100, 500 and 1,000, as well as in powder form in ¼-pound and 1-pound bottles. Sharp & Dohme, Philadelphia 1, Pa.

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Crystalline Penicillin G

POTASSIUM SALT

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Virtually free from local pain on intramuscular or subcutaneous injection.

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Administered in oil and wax mixtures it produces assayable blood levels for 24 hours in most cases.

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Available in vials of 100,000 . . 200,000 . . 500,000 units.

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Available also in a Romansky Type Formula (in oil and wax) presenting 300,000 units of crystalline penicillin G potassium per cc., for intramuscular or subcutaneous injection, in 10 cc. size serum type vials. Supplied also in tablets for oral administration (Tablets Buffered Penicillin-C.S.C.) containing 50,000 units of potassium penicillin per tablet, in bottles of 8 and 48 tablets.

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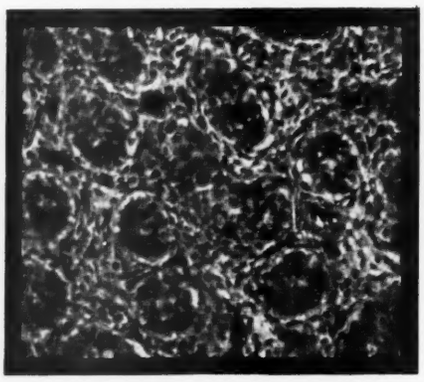

Photomicrograph of undescended human testicle. Transection of tubules. Masson III stain.

Complete information on Perandren and Metandren Linguets will be sent to any physician on request. Write Professional Service Dept.

1. Thompson, W. O.: J.A.M.A., 132: 185, 1946.

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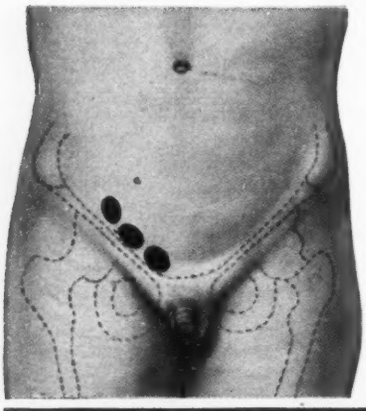
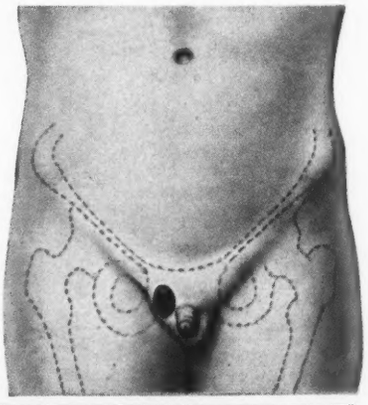


MALPOSITION OF THE TESTICLE

Right abdominal testicle. Three positions of the undescended testicle in the abdomen.

Right pubo-scrotal testicle. Position of the undescended testicle in the pubo-scrotal region.



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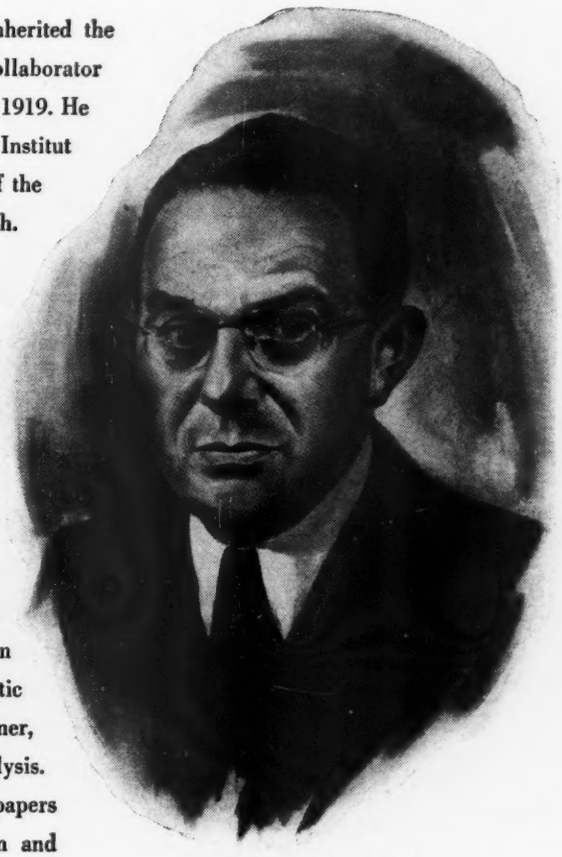

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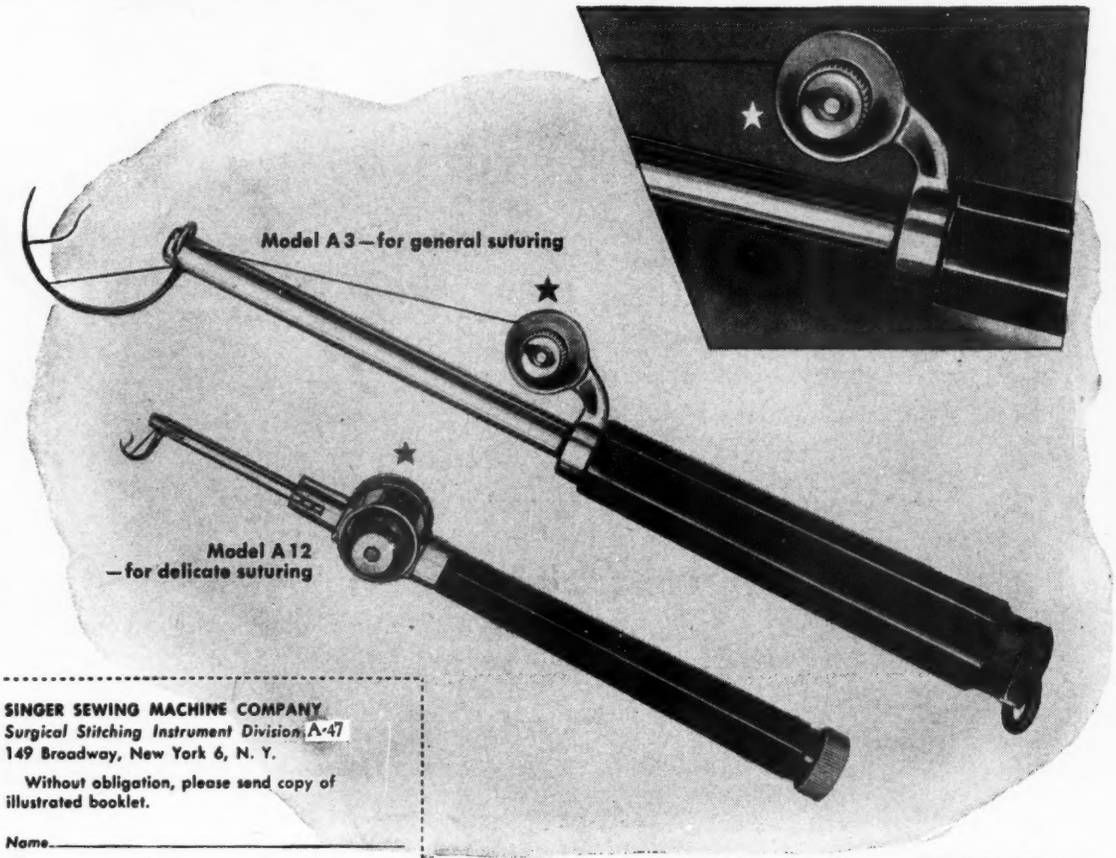

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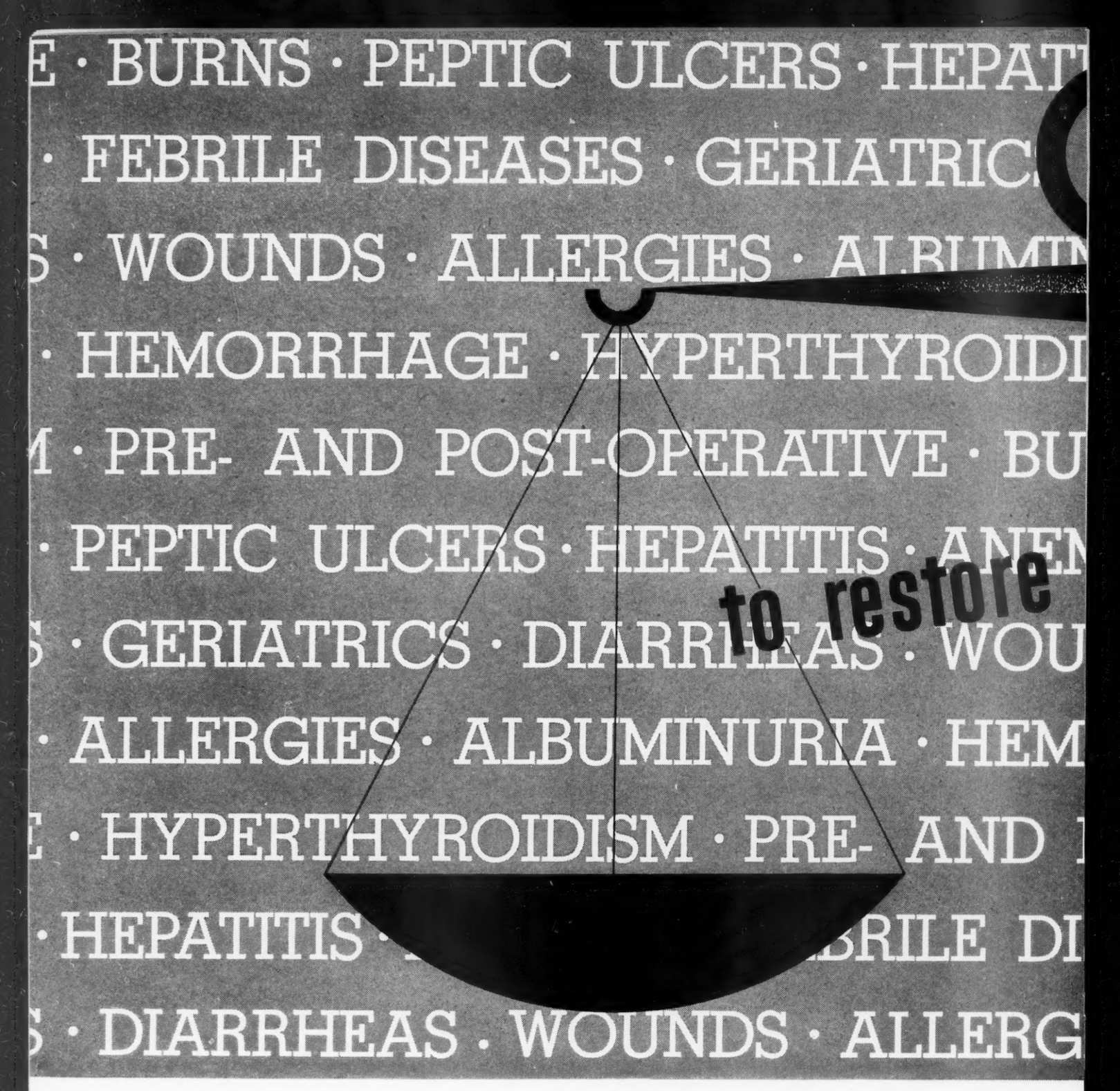
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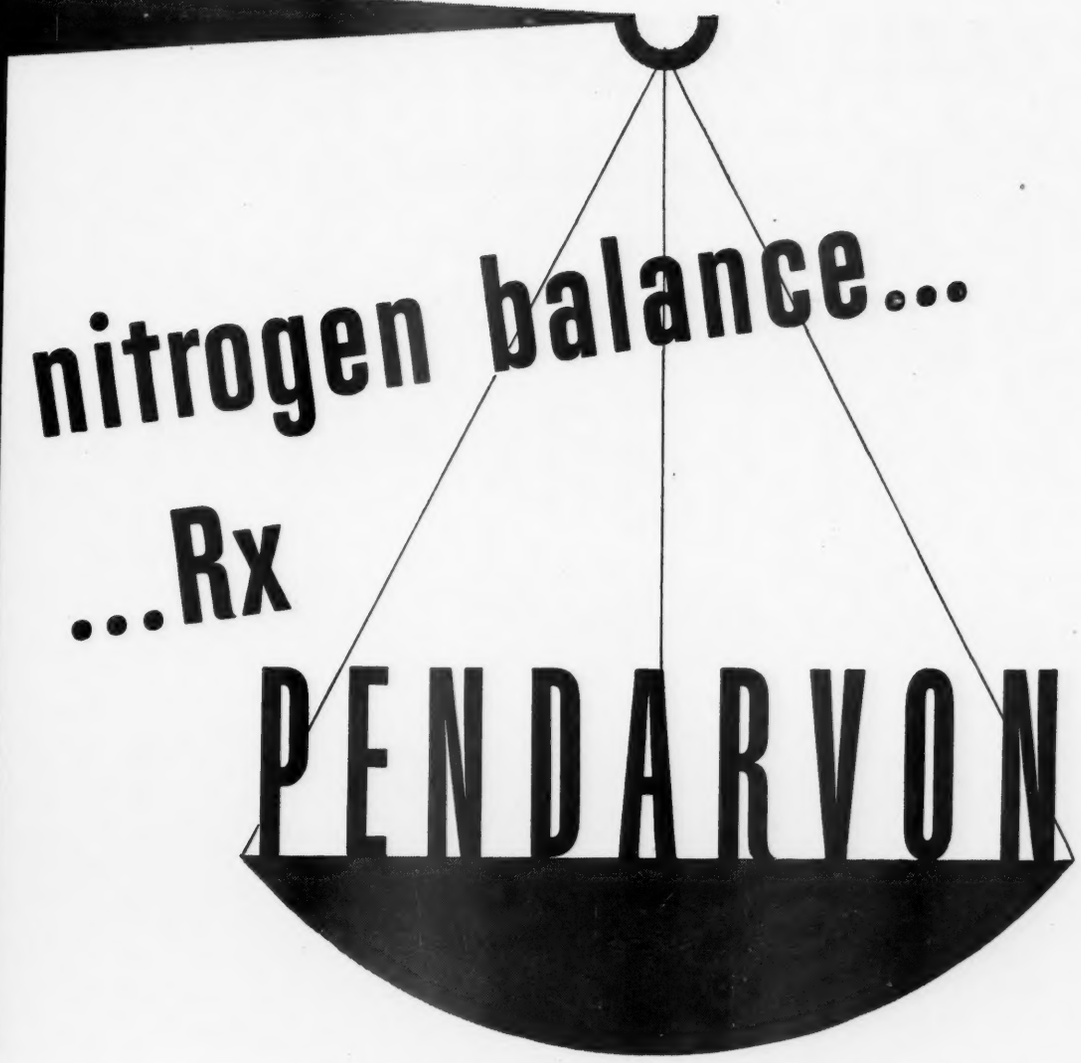

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Editorial

SCARCITY OF NURSES AND HOSPITAL COSTS

WE read that living costs still are going to rise somewhat. Farm products, at wholesale, are up 159 per cent since 1939. Food is up 129 per cent in the same period. Since before the war building materials have risen 91 per cent. In the same period textile products, at wholesale, have gone up 94 per cent.

Recently registered trained nurses have received a substantial rise in pay. Anyone who knows the facts agrees that they received what was their just due. But the item of increased pay of trained nurses, plus the increased cost of food, medical supplies and the increased wages of civilian employees have about broken the budget-back of many hospitals. Just recently one large voluntary hospital had to add $60,000 to its budget for the increased remuneration of the nurses. The hospital is filled to capacity. Its staff physicians have trouble in reserving beds when needed; yet to keep out of the red too deeply, the cost per day per patient has been going up steadily. Ten years ago a semi-private bed that cost $4.00 per day now costs $8.50; a private room that originally cost $10.00 now costs $18.00 or $20.00. Nevertheless, with these increases in income the business office is having severe headaches.

Even though they have been granted marked increases in pay the scarcity of trained nurses is marked. They have been attracted to the Veterans Bureau, the Armed forces and to industry. Even special duty nurses who receive $10.00 for eight hours of duty, plus their hospital board, are hard to procure at times.

Therefore, pleasure was evidenced in many quarters when we heard that the American College of Surgeons had approved of nursing attendants, nurses aids or the so-called practical nurse for hospital duty. It is hoped this will fill a need that somehow just must be filled. Inasmuch as most States require that a candidate for the degree of Registered Nurse have at least a high school education (and many insist on one language, chemistry and physics), and because the course of training covers three calendar years, many young women have turned and continue to turn to other fields for careers. Training school registration has taken a decided drop. When a patient is acutely ill he must be cared for by a trained nurse; but from observation and experience, we cannot see why the ministrations of a trained nurse are necessary during the usual period of convalescence. Surely anyone possessed of fair intelligence and common sense can wash and powder a patient, attend to his bed pan, carry the food trays, get drinking water and do the many little chores that

make for comfort; and these duties (plus endless paper work) make up the majority of work hours.

Women given short courses in practical nursing and then paid an adequate wage will fill a great hospital need. Speed the day when it is put into operation!

During the War the American Red Cross trained nurses aids at a cost of about $40.00 per aid. Without these public spirited women working in our hospitals without remuneration, things might have been chaotic. But aside from the fine work they rendered they proved that an intelligent person with a little training can assume a great part of the nursing load of a hospital.

T. S. W.

Books and World Recovery. The desperate and continued need for American publications to serve as tools of physical and intellectual reconstruction abroad has been made vividly apparent by appeals from scholars in many lands. The American Book Center for War Devastated Libraries has been urged to continue meeting this need at least through 1947. The Book Center is therefore making a renewed appeal for American books and periodicals—for technical and scholarly books and periodicals in all fields and particularly for publications of the past ten years.

The generous support which has been given to the Book Center has made it possible to ship more than 700,000 volumes abroad in the past year. It is hoped to double this amount before the Book Center closes. The books and periodicals which your personal or institutional library can spare are urgently needed and will help in the reconstruction which must preface world understanding and peace.

Ship your contributions to the American Book Center, c/o The Library of Congress, Washington, 25, D. C. freight prepaid, or write to the Center for further information.

Original Articles

MANAGEMENT OF EXTENSIVE COMPLETE DEFECTS IN LONG BONES*

JAMES E. BATEMAN, M.D.
TORONTO, ONTARIO

ONE of the most challenging problems in orthopedic surgery has been the replacement of extensive defects in long bones. The many serious residual injuries resulting from World War II has necessitated evaluation of old principles and if possible, establishment of improved methods. A significant defect of bone rarely occurs without considerable damage to associated structures. This may include skin, nerve and muscle; often there is involvement of all the soft tissue. Bone reconstruction should not be undertaken until the damage to these associated structures has been properly repaired.

Infection. The structures in such a damaged limb have been grossly traumatized and devitalized, leaving a situation in which further trauma may lead to reactivation of dormant foci. In addition to the risk of possible reinfection, new foreign material will be necessary for sound repair. The reconstruction will need large cortical grafts which are not easily revascularized, and this results in an additional strain on the protective mechanism of the area. The policy of delaying before definitive operation is undertaken has been the subject of such discussion, yet regardless of modern chemotherapy, it is believed that all evidences of infection should have disappeared for at least six months before extensive reparative procedures are undertaken. Even after such an interval, it is not an uncommon experience to find small pockets of infection and sequestra at the time of such an operation.

Consideration of the Skin. Poor skin covering can be the cause of many failures. Whether the area has healed by primary intention or by granulation, it will have done so at the expense of bone and soft tissue, producing a contracted depressed scar. When the replacement of lost bone is undertaken in such an area, there will be a resultant increase in the circumference of the extremity. Unless due allowance is provided for this increase in girth, closure of the wound will be difficult or impossible.

Poor blood supply of the area will further jeopardize the healing of the skin. A thinly covered area may break down with disastrous loss of the bone grafts, no matter how well the internal reconstruction has been done.

The exposures necessary for reconstruction are extensive and attention must be paid to devitalized adjacent areas as well as to the defect. For example, the operative incision may heal well but a devitalized scar on the opposite side of the limb may slough, precipitating failure.

For these reasons, it is of the greatest importance to assess skin vitality carefully and repair the damage by full thickness grafts, either by the sliding or pedicle methods, before proceeding with bone reconstruction.

Vascular and Nerve Lesions. Many cases with complete shaft defects have also suffered damage to nerve and vessel. The vascular occlusion as a rule will have been relieved through collateral circulation by the time reconstruction is to be considered.

* From the Orthopaedic Division, Christie Street Hospital.

TABLE I

TYPE OF GRAFT	METHOD OF FIXATION	WEIGHT SUSTAINED BEFORE FRACTURE
Inlay	Twisted Wire	12 Pounds
Inlay	Tied Wire	42 "
Inlay	Vitallium Screws	52 "
Diamond Inlay	Tied Wire	6 "
Onlay	Vitallium Screws	90 "
Dual Onlay	" "	196 "

Nerve injuries, however, need further treatment. During World War I and the early part of World War II, the tendency was to treat the bone as the primary procedure, leaving the nerve until later. Experience at our hospital indicated there are many advantages in first dealing with the nerve and then the bone. The reasons are as follows:

1. Early exploration and suture of the nerve may be done with less danger of activating previous infection. Less rugged manipulation is necessary and introduction of foreign material is of a minimum degree.

2. It may be necessary to take advantage of the gap or shortened extremity to allow an end-to-end suture.

3. There are certain locations where preliminary transplantation of the nerve will facilitate subsequent bone reconstruction. For example, in defects of the lower shaft of the humerus, the radial nerve repair may be done and the nerve transplanted anteriorly, leaving the field completely free for subsequent grafting of the shaft.

4. We now know that early suture of nerves is beneficial. The nerve may be sutured and regeneration then continues while one awaits the lapse of an adequate time following infection of bone. By such a routine, the patient will be saved many months of time and the chances of regeneration are improved.

Choice of Graft. Having satisfactorily solved these preliminary problems, the surgeon is frequently still faced with a difficult task in bridging a gap. The further management of these cases then involves the consideration of the type of bone graft and methods of fixation to be used in such circumstances.

In selecting the type of graft, the histological process of bone repair must be kept in mind. The fate of the graft has been a controversial subject for a long time but it is apparent we must expect that the greater part of bone which is cut free from its circulation will die and become absorbed and replaced. The portion of the graft which survives is small, but it can be a most important contribution to the process of regeneration. Surface cells bathed with lymph may survive, while those in the lacunae become necrotic and die. The open Haversian canals are infiltrated by capillaries accompanied by osteoblasts and dead bone is excavated. As the vessels progress, there is a creeping substitution by new cancellous bone. It is difficult to say definitely which cells and what percentage of cells in parent tissue are responsible for ultimate union. Under different circumstances, participation may be in different degrees, similarly, some power of adaptation must be expected in the rearrangement under new environmental influences.

Basic Requirements. The defect is best replaced by an autogenous graft with sufficient living elements to be of some aid in the healing of the defect. The graft should be so applied that contact of graft

and fragments is long enough and intimate enough to use the osteogenic qualities of endosteal and periosteal surfaces of both parts. During the early months, the chief process is one of absorption and unless the graft is sufficiently strong to withstand this process until enough new bone is developed to stand the strain, there may be destruction of any freshly formed bone. In extensive defects, the graft will be relied upon to effect perfect internal fixation until union is firm enough to stand the strain of moderate motion and in the meantime, to maintain adequate bridging of the gap.

Source of Bone. These requirements of length, strength and osteogenesis may be best fulfilled by using cortical bone for strength and cancellous bone for osteogenesis. In loose textured bone such as ilium or rib, the process of absorption occurs rapidly so that bone of a more compact structure is necessary to splint the area adequately. To provide extensive grafts that resist stress, the best source is the medial surface of tibia or shaft of the fibula. Cancellous elements from tibia or ilium may be added for osteogenesis.

Application of Bone Grafts. In dealing with non-unions, there has been continued controversy over the best method of applying and fixing the bone grafts. Therefore, in the repair of extensive defects, the methods need to be even more thoroughly evaluated and assessed. Occasionally, it will be impossible in large defects to use the most perfect mechanical fixation because of the extent of the gap and shortness of the remaining host fragments.

Medullary Grafts. The disadvantages of this method have long been known. The fixation provided may be defective and often not entirely secure. The method minimizes the osteogenic properties of the host since it blocks the medullary canal. Apart from participation as a combined procedure, it is apparent that this technic has little place in the repair of complete defects.

Sliding Graft. This method has a definite place in non-unions; however, critical analysis demonstrates disadvantages when it is applied to the bridging of gaps. It is preferable to use a graft taken from a normal bone and avoid using a sclerosed or thin atrophic fragment as a donor. These grafts also tend to be of a looser texture and become more rapidly absorbed, providing poor fixation. Where this method may be supplemented with an additional graft, it will be useful in certain defects.

Inlay Crafts. This method makes full use of osteogenic properties of graft and host, but in doing so, it sacrifices valuable tissue. This may be of minimal importance in a simple non-union but it is a major factor in bridging gaps. If the original attempt fails for any reason, particularly should there be reinfection, the resulting defect has been increased and the whole problem of reconstruction made much more difficult. In addition, it is a poor mechanical principle to sacrifice part of an area to which fixation is applied. The size of the graft is limited by the size of the bone into which it is inserted so that a weaker graft and less new tissue is inserted. For these reasons, except in certain cases, inlay fixation does not appear adequate.

Diamond Inlay. This is an excellent method since it completely removes sclerotic bone of the host and secures intimate contact. In addition, the contact that it gains is at the expense of less bone from the host than an ordinary inlay graft. However, this method has definite limitations because of the size of grafts used and the mechanics of the fixation. Since the host areas may be too rigid to allow insertion under tension, its use is limited to such areas as radius and ulna. In addition, it is a difficult graft to do properly, but in expert hands, and in proper areas, an excellent result may be obtained.

Onlay Grafts. The advantages of this method are that an extensive area of contact between new bone and host is provided. The grafts may be securely fixed without damaging the host bones. The width of the graft is not limited by the size of the host bones as in the inlay technic.

The method of fixation is a simple one and lends itself to many of the problems.

Dual Onlay Grafts. Such a technic has all the advantages of a simple onlay fixation and in addition, gives improved resistance against stress and strain. The grafts may be applied over a broad surface affording a better grip of the host bones, particularly in small atrophic fragments close to joints. A strong osteogenic element is introduced by the two large endosteal surfaces and a trough or gutter is formed in which cancellous bone may be packed or anchored in a protected position, minimizing complete absorption.

Investigation of Fixation Methods. These are the usual arguments advanced when dealing with the merits of the various methods. In addition to the problem of osteogenesis, the repair of extensive defects presents further special difficulties. These have to do with resistance of the graft, against stress and strain for prolonged intervals, and with the provision of perfect mechanical fixation of host and graft.

To evaluate these methods, a series of experimental grafts was done, using fresh beef bone. Defects of 2 inches were bridged by various methods. The host bones were as identical as possible in size and shape and the gap bridged was at the same point in the shaft in each case. The grafts were then subjected to direct stress. This stress was applied through a steel ring from which increasing weight was suspended. The weight was gradually increased by adding No. 2 lead shot to a container. Several containers could be added to the same suspension. Between the grafts and the weight, a scale was inserted. The host bones were fixed in metal pipes, the ends being cut to fit snugly, preventing slipping and rotation. The No. 2 lead shot was added slowly at a uniform speed. The grafts were fixed by the usual different methods available, including twisted steel wire, tied wire and Vitallium screws. All grafts were solidly fixed. When wire was used, two loops at each end maintained the graft and similarly, for screw fixation, two Vitallium screws were used at each end. Stress was applied slowly until the graft broke. The effects of the stress, the weaknesses and process of breaking were recorded by a slow motion camera, and carefully studied.

RESULTS

Type of Graft	Method of Fixation	Weight Sustained before Fracture
Inlay	Twisted wire	12 pounds
Inlay	Tied wire	42 pounds
Inlay	Vitallium screws	52 pounds
Diamond inlay	Tied wire	6 pounds
Onlay	Vitallium screws	90 pounds
Dual onlay	Vitallium screws	196 pounds

ANALYSIS OF RESULTS

Inlay Graft with Twisted Wire Fixation. Examination of the slow motion record showed that movement appeared early at the point of wire fixation. (Figs. 1A and B.) The graft was seen to bend slightly and then the proximal end shifted beneath the wire, allowing greater range of stress application. The graft finally gave at the point of wire insertion through its substance. (Fig. 1C.) All wires were snug prior to applying stress but examination following the breakage showed that the twist in the wire gave slightly under stress, allowing movement and hence early breaking of the graft.

Inlay Graft with Tied Wire Fixation. No movement of the graft was demonstrable as stress was increased and breakage came through the graft itself at 42 pounds. (Fig. 2A and B.) The fixation in this case was by wire loops tied with the Harris wire tiers. This appeared as a superior method of fixation for two reasons: (1) The wires remained snug and there was no loosening at the notch to allow shifting of the graft, and (2) the graft was not weakened by a transverse slot, through its substance, which could give way at low stress.

Inlay Fixation with Screws. No movement of the graft was demonstrable prior

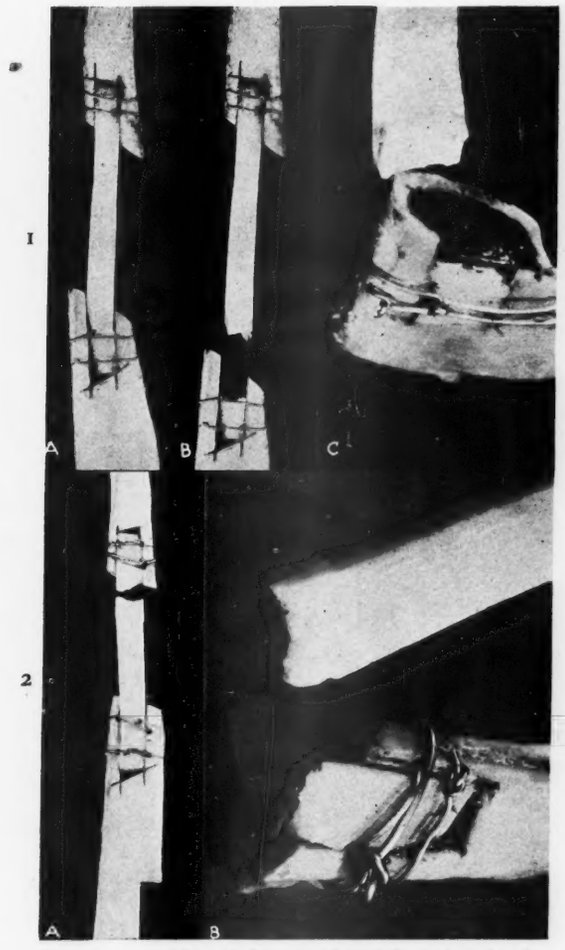

Fig. 1. A and B, inlay graft with twisted wire fixation; C, close up view of point of fracture through the tunnel in the graft.

Fig. 2. A, inlay graft with tied wire fixation; B, close up view shows fracture line through graft substance, but the fixation has not weakened the graft itself.

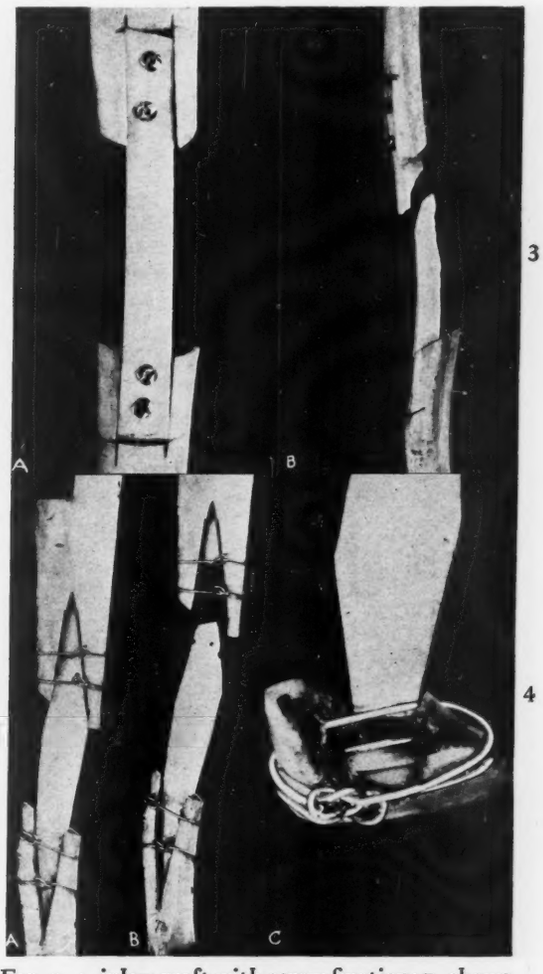

Fig. 3. A, inlay graft with screw fixation; B, shows the fracture line through the graft and not at the point of fixation.

Fig. 4. Diamond graft A before and B after fracture; C, close up view shows that the weak point is at the wire fixation through the smallest portion of the graft.

to the breakage point. Fracture occurred through the graft at 52 pounds. Both fragments were firmly held in place and there was no slipping of the fixation. (Fig. 3.)

Diamond Inlay. This graft (Fig. 4) appeared solid with fixation but fracture came quickly after application of only 6 pounds. In examining the motion picture record, the graft was seen to twist very slightly and quickly break through the point of wire fixation at the proximal end. The fracture was again through the tunnel of wire fixation and at that portion where the grip of the fixation is weakest, at the distal end of a tapering graft. (Fig. 4C.) In comparing this with the previous inlay fixation that broke at 12 pounds, it is apparent that the stress sustained is directly proportionate to the size of the grafts at the point of fixation, that is, about half that of the previous simple inlay fixation.

Onlay with Screw Fixation. The onlay graft used was the same length but just slightly wider than the previous inlay grafts. The reason for using a very slightly broader graft was that often this may be possible clinically, whereas fixation of the corresponding area by the inlay graft could be done only by a narrower piece of bone controlled by the size of the trough which may be prepared without weakening either side. This graft showed no changes until 70

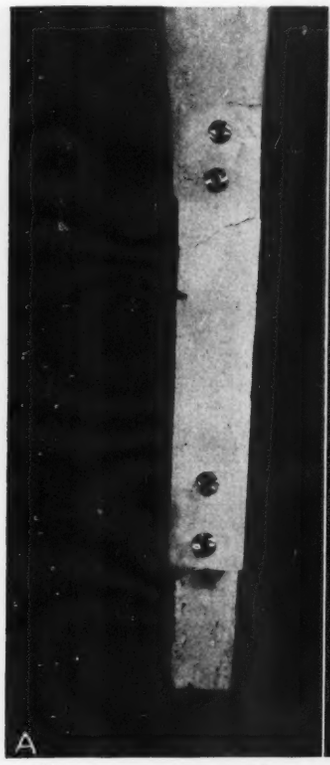

FIG. 5. A and B, onlay graft with screw fixation. The breaking point occurred through graft substance at 90 pounds.

FIG. 6. Dual onlay graft following breakage. The fracture occurred after 200 pounds had been added, and through the graft secondarily extending to the points of fixation.

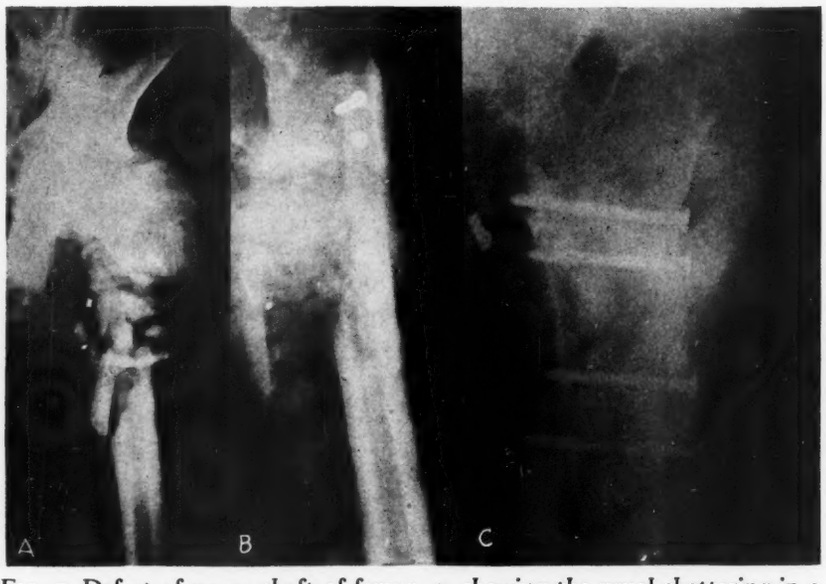

FIG. 7. Defect of upper shaft of femur. A, showing the usual shattering in a complete defect; B and C, following dual onlay reconstruction.

Fig. 8. Reconstruction of defect in femoral shaft.

Fig. 9. Fig. 10.

Figs. 9 and 10. Before and after dual grafting of complete tibial defect.

FIG. 11. A and B, reconstruction of a defect by a single tibial graft apparently solid; C and D, before removal of plaster without weight bearing this graft has fractured.

FIG. 12. Complete tibial defect complicated by amputation of opposite leg.

FIG. 13. The same as Figure 12 following reconstruction.

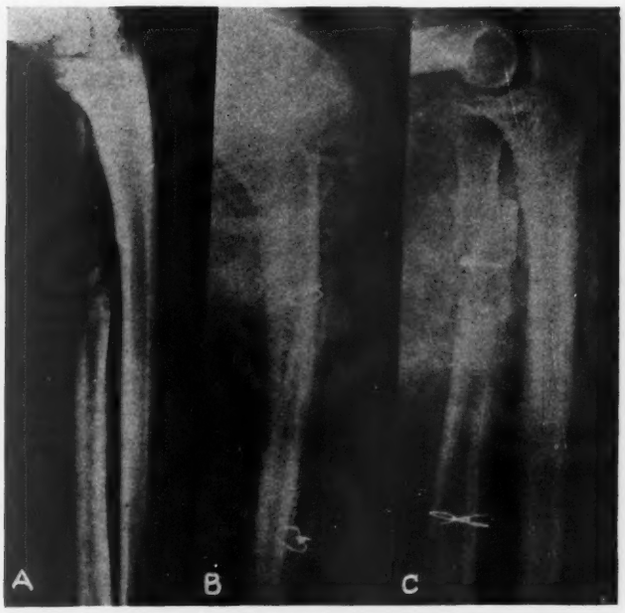

FIG. 14. Defect of upper shaft of radius before and after reconstruction.

pounds, at which time a slight bend was apparent. The fracture was not produced until 92 pounds had been added. The graft fragments were still firmly united to the host bones but the fracture extended to the proximal screw hole. (Fig. 5.)

Dual Onlay Fixation. No change was apparent in either graft after 150 pounds had been added and it was believed that fracture might not be possible within a practical range. The graft finally broke at 196 pounds. Analysis of the slow motion record showed that the superior graft broke at the distal end followed by rapid disruption of the inferior graft and proximal fixation. The primary break came through the bone with secondary disruption of the distal point of fixation. (Fig. 6.)

DEFECTS OF INDIVIDUAL BONES

Femur. Injuries involving complete defects of femoral shaft may be so severe that life is lost or more frequently, amputation follows because of vascular disturbances. Those limbs which survive often have a shattered comminuted shaft with a partial defect. This defect may be bridged by a solid cortex on one side or by frail comminuted fragments which fracture easily, and result in a pseudoarthrosis. (Fig. 7.) Since there is but a single shaft and strong muscle pull applied to the distal fragment, defects will be shortened by the muscle pull if there are no interspaced small fragments. Those defects which remain are best bridged by a large cortical dual onlay graft fixed by Vitallium screws with abundant cancellous chips inserted. (Fig. 8.)

Tibia and Fibula. Similar considerations apply to large defects in the lower leg. The destruction of skin, vessel, nerve and bone may have been so extensive that amputation was a far better solution than reconstruction. This argument applied in the early stages of the case and has usually been settled before the patient arrived on this Orthopedic Service. An injury which leaves the fibula intact will produce a con-

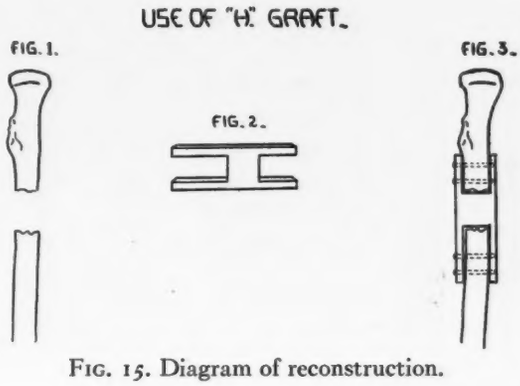

FIG. 15. Diagram of reconstruction.

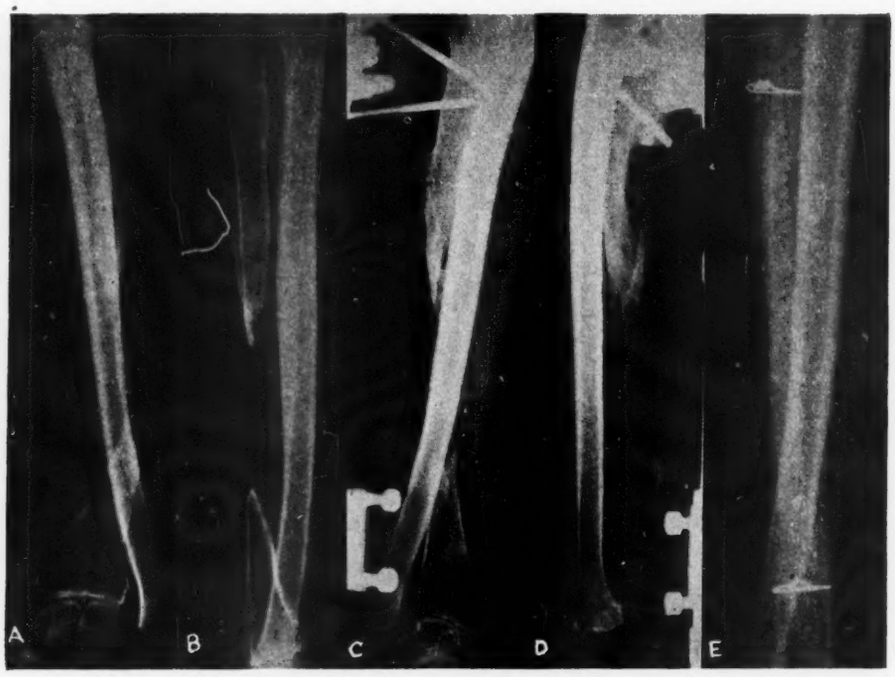

Fig. 16. Defect of mid-shaft and radius A and B before, C and D after correction of deformity; E, reconstruction by diamond graft.

siderable defect in the tibia which is maintained by the intact strut. Such defects lend themselves well to the use of dual onlay grafts and screw fixation. (Figs. 9 and 10.) Frequently, a single cortical graft will not be sufficient. (Fig. 11.) Occasionally an amputation of the other leg further complicates the reconstruction since the supply of good cortical bone is thus limited. These defects may be treated by a massive sliding graft supported by bone from the iliac crest. (Figs. 12 and 13.) A fibular transplant, it is believed, is best reserved for a final attempt should the above procedures fail. In addition, the intact fibula while it maintains the gap, still aids materially in the immobilization of the tibial graft and fragments. Despite the size of the gaps, correction of angulation and deformity usually may easily be performed.

Radius. Defects of the radius produce considerable deformity, possibly more than any other long bone. The reconstruction of the radius is considered in the three regions,

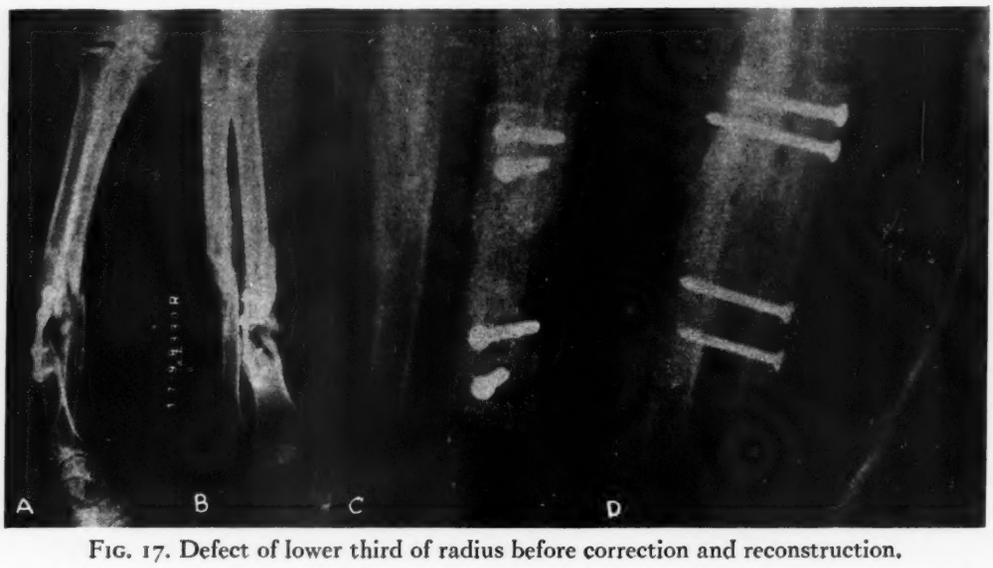

Fig. 17. Defect of lower third of radius before correction and reconstruction.

upper, middle and lower, since specific problems develop at different levels.

Upper End. Defects in this region may be satisfactorily corrected by a fibular graft of the "H" or reversed diamond type. (Figs. 14 and 15.) Full exposure of the shaft for fixation and control of rotation may be a little difficult. Simple, single onlay grafts are not quite suitable because of the shape of the shaft and interference with adjacent structures. The diamond method of fixation is not suitable since in splitting the small proximal segment, the crack may extend into the neck or head.

Central Shaft. Defects in this region may be ideally treated by a properly executed diamond inlay graft. (Figs. 16D and E.) The graft is best fashioned with a long lateral curve producing a somewhat cigar-shaped piece rather than an acutely angled diamond. Preliminary correction of the radial deviation which produces a protuberant lower end of ulna is necessary in bridging defects at this site. (Figs. 16A, B and C.) The correction may be carried out by preliminary external skeletal fixation followed by a diamond graft.

FIG. 18. The same following correction and reconstruction with dual grafts.

Lower End. Significant defects of the

FIG. 19. A and B, a similar defect in radius following a diamond graft. The weak point of fixation can be seen at the lower end corresponding to the weak area found in the experimental grafts. Such a defect would have been better had the deformity been corrected first followed by dual grafting; C and D, reconstruction of central shaft by diamond graft twenty-five years ago. The shaft has been well reconstructed.

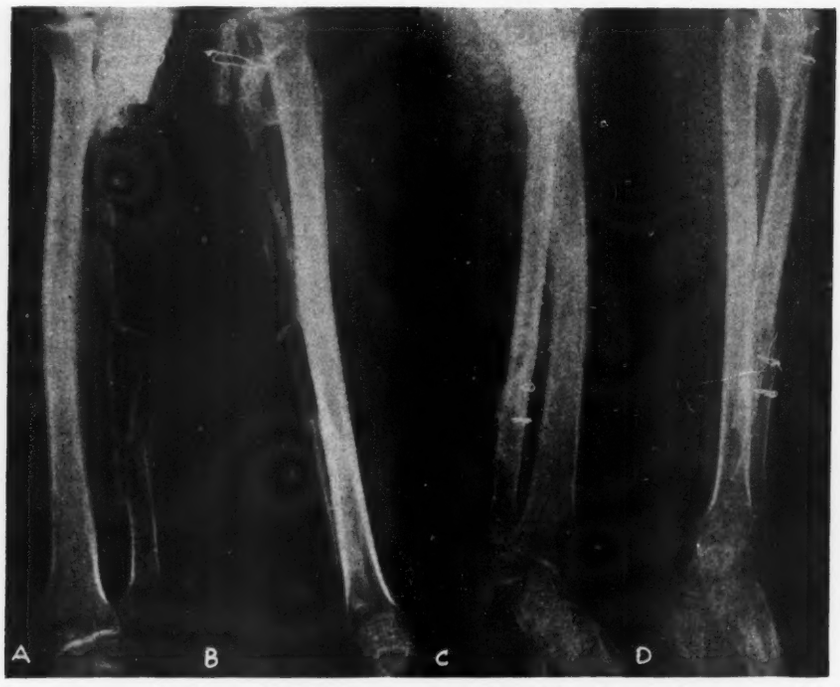

FIG. 20. A and B, large defect in ulna; C and D, following replacement with fibula.

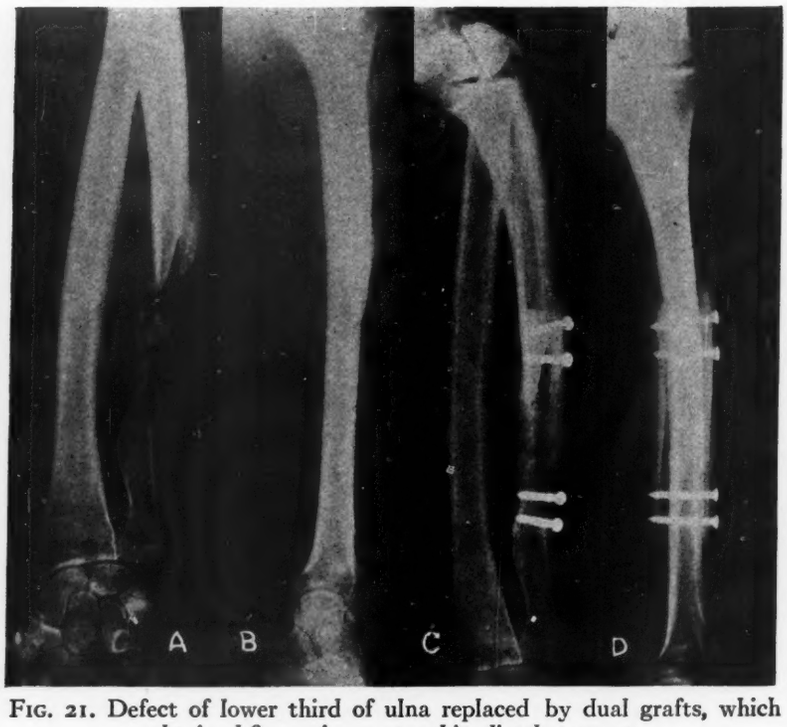

FIG. 21. Defect of lower third of ulna replaced by dual grafts, which obtained firm grip on atrophic distal segment.

lower end also produce moderate deformity. (Figs. 17 and 18A and B.) The most difficult deformity to correct is the supination. The graft used must be able to stand moderate rotatory stress and firmly grasp the short lower end of the radius. These requisites are best fulfilled by a dual graft which will grasp the small radial fragment in pincer-like fashion, allowing correction of rotation. (Fig. 18.)

Ulna. Long defects are frequently encountered in the ulna and lend themselves well to replacement by the shaft of the fibula. (Fig. 20.) There is usually little deformity to be corrected and minimal rotatory strain is placed upon the graft. Fixation of grafts to the host fragments is best obtained by the onlay method, with the graft extending for at least 1½ inches to 2 inches in contact with the ulnar fragments. The remaining fragments of ulna are frequently small and do not lend themselves to splitting or inlay fixation. The length of overlap for onlay fixation is important in long defects of 8 inches to 10 inches to insure solid union. Defects of the lower shaft of the ulna may best be repaired with small dual grafts where the distal fragment is small, atrophic and difficult to immobilize. (Fig. 21.)

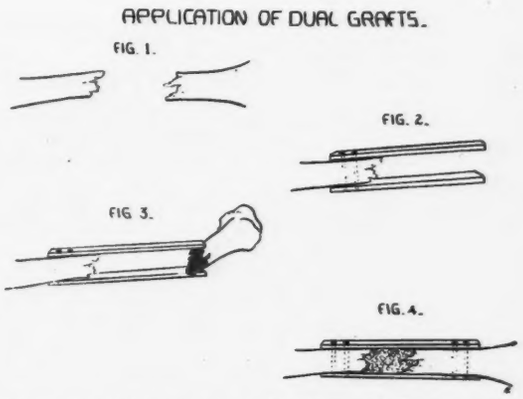

FIG. 22. Scheme of application of dual grafts. Accurate application and control of the grafts occasionally will be accomplished more easily by applying the grafts to one fragment first, levering the second into position as illustrated.

Humerus. Consideration of complete defects in the upper arm corresponds somewhat to similar defects in the thigh since there is a single shaft and the strong muscle pull tends to shorten the gap. Every possible attempt must be made to save an arm despite extensive skin, vascular and nerve damage. In these days of improved plastic repair and reconstruction, amputation at any level can be considered only after every

FIG. 23. Complete defect of mid-shaft and humerus before and after reconstruction.

possibility of conservative therapy has been thoroughly considered. In the humerus, deformity is easily corrected in the midshaft area but less easily in the lower third. Most complete defects of the humerus are best treated by dual onlay fixation, (Figs. 22 and 23), this applies particularly to defects of the lower third in which the short distal fragment may be held in a pincer-like grip by two grafts.

SUMMARY

The general principles in dealing with extensive and complete bone defects have been outlined. These include careful management of infection, preliminary skin repair and early treatment of damaged associated structures. An experimental investigation of the effects of one form of stress on the various methods of graft insertion and fixation has been outlined. The results indicate the superiority of single and dual massive onlay grafts and screw fixation. These principles have been applied and illustrated in a discussion of the best forms of bone replacement in the different long bones.

The author wishes to thank Dr. R. I. Harris, Dr. G. M. Dale and Dr. H. M. Coleman of the Orthopedic Service for their kind permission to use Figures 8, 10 and 16.

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USE AND ABUSE OF INTESTINAL DECOMPRESSION TUBE

A STUDY BASED UPON TWO HUNDRED CASES*

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IN the past ten years, with the introduction of the long intestinal decompression tube, and newer methods facilitating its passage through the pylorus and so well down into the gastrointestinal tract, lives have been saved that might otherwise have been lost. Many articles[1,2,3,4] have appeared extolling the virtues of the tube in the treatment of intestinal distention. Then its use in the non-operative treatment of certain types of intestinal obstruction began to appear.[5,6,7,8] A glance through the Quarterly Cumulative Index Medicus for this past decade reveals many articles discussing this new method of treating certain types of intestinal obstruction by intubation alone. The trend has gone so far, that in many hospitals, patients admitted with a diagnosis of possible bowel obstruction have a long intestinal decompression tube passed, usually by the intern and then a period of waiting is begun. Some men expect the intestinal decompression tube unaided to relieve the patient of his distention and so obviate the necessity for surgical intervention.

Many men fail to realize that the intestinal decompression tube is merely an instrument like a hemostat and will help the patient only so far as the knowledge of the surgeon in the use of the tube. Even in the passage of the long intestinal decompression tube, many surgeons are completely uninformed or consider it the task of the intern to pass these tubes and to supervise the downward progress. We have seen the operator neglect to tie off the neck of the sac containing the mercury, (Fig. 15) and then pass three feet of long tube into the stomach and put the patient through various acrobatics in an effort to get it to pass. The only result of this type of activity is failure because of coiling in the stomach or knot formation and a leakage of the mercury through the lowest hole.

CASE REPORTS

CASE 1. L. C., a thirty-year old white man, was admitted to Grace Hospital on July 13, 1946, with a diagnosis of acute bowel obstruction. On admission he appeared acutely ill. He had been vomiting for two days and had passed no gas per rectum for the same period. His abdomen was greatly distended and tender. He had been operated upon twice previously, once for appendicitis and once for bowel obstruction. At this last operation an anastomosis was performed between the ileum and the transverse colon. A Cantor tube was passed upon admission. Check films taken twenty-four hours later revealed the tube in the distal jejunum. The distention gradually decreased and his abdomen became soft. On the fourth day, he passed gas per rectum. On the fifth day, he was taken to the operating room and the abdomen opened. The tube was found to have passed through the jejunum and its tip came to rest at the site of the previously performed ileotransverse colostomy. At this point, the small bowel was found to be obstructed by loops of ileum passing around the anastomosis. The anastomosis was taken down and the continuity of the transverse colon was re-established by

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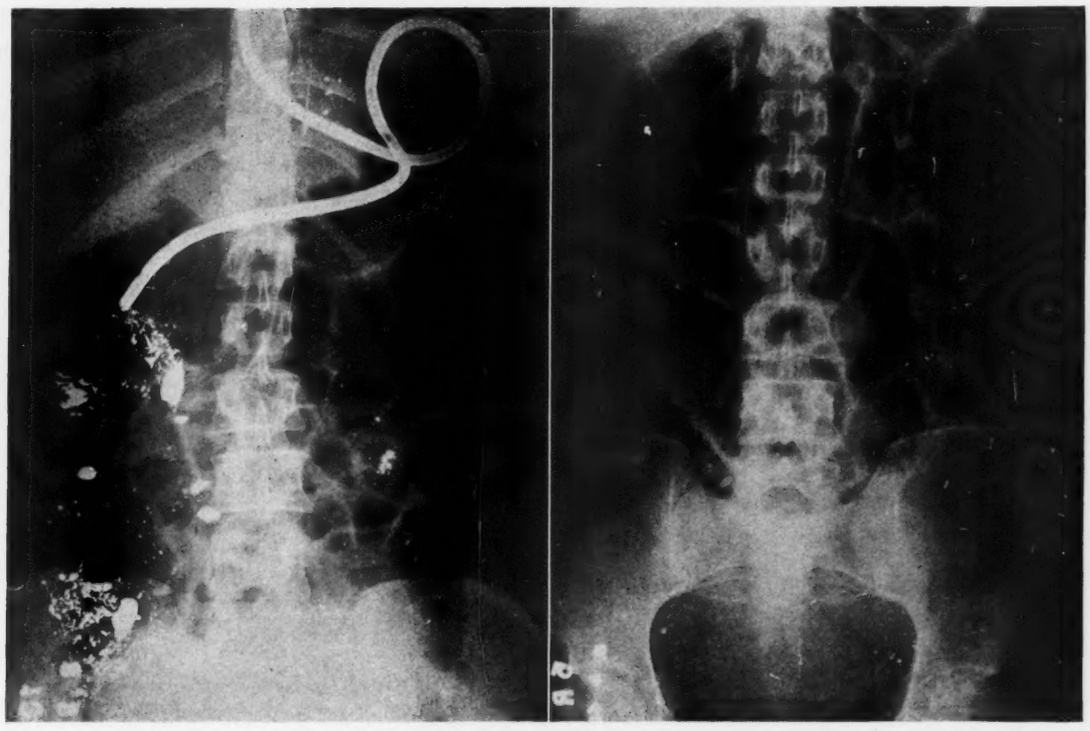
Fig. 1. Note the intestinal distention. Much of the mercury had leaked out of the balloon and is disseminated along the gastrointestinal tract. Note also that the "head" of the tube is in the duodenum.

Fig. 2. Distention has decreased considerably. In spite of the fact that very little mercury remains in the tube "head," the tube has moved further along the gastrointestinal tract. A loop of tube has moved along faster than the tube "head" and is found along side of it. Note the decrease in amount of mercury in the gastrointestinal tract.

an end-to-end anastomosis. The ileum was resected and an end-to-end anastomosis done. The Cantor tube was removed accidentally by the anesthetist so a Witzel enterostomy was performed six inches proximal to the end-to-end anastomosis in the small bowel. The patient became distended postoperatively and began to vomit. The tube was reinserted. The resident who passed this tube neglected to tie off the end of the balloon. As a result the mercury ran out of the bag. A twenty-four hour check film showed that the tube head was in the duodenum but almost all the mercury had run out of the bag and was found throughout the gastrointestinal tract. (Fig. 1.) A forty-eight hour film showed that the tube had advanced to the duodenojejunal flexure and that a loop of tube had moved along with the tip. (Fig. 2.)

It is interesting to note that even though there was very little mercury in the balloon, yet the tube had passed through the pylorus into the duodenum. The decompression obtained, however, was good. For the next two weeks globules of mercury were found on the dressing of the enterostomy. The patient left the hospital greatly improved.

Case II. H. G., a thirty-two year old white woman, was admitted to Grace Hospital on August 3, 1946, with a diagnosis of acute pelvic peritonitis and paralytic ileus. A Cantor tube was passed by the resident who forgot to tie off the bag. As a result most of the mercury leaked out and was found in the small bowel. In spite of this the tube was found to have passed through the pylorus and at the twenty-four hour check film it was found in the second portion of the duodenum. (Fig. 3.) The next day the tube had passed into the jejunum. The abdominal distention rapidly decreased, (Fig. 3B) so that by the third day the abdomen was quite flat. On the seventh hospital day the patient began passing flatus per rectum. On the tenth hospital day, the tube was removed. The patient had a bowel movement on the eighth and tenth days. Globules of mercury could readily be seen in the stool. The patient made an uneventful recovery. A left salpingo-oophorectomy was done on the fourteenth hospital day.



A B

FIG. 3. A, the mercury has almost completely leaked out of the tube "head" and yet the tube passed through the pylorus into the duodenum. There is a spread of mercury throughout the gastrointestinal tract. Compare this film with Figure 3B and note the marked decrease in distention. B, flat plate of patient shown in Figure 3A. Note the marked intestinal distention.

These two cases exemplify the fact that even under the worst possible conditions of handling the tube will usually pass through the pylorus. They also demonstrate rather well that mercury is not absorbed and is completely innocuous being excreted by the patient with every bowel movement.

We would like to emphasize that the intestinal decompression tube is a tube that will, if properly used, decompress the gastrointestinal tract of the patient, and nothing more. With this fundamental principle in mind, that the only function of this tube is intestinal decompression, we can now consider just how its use is of value and under what circumstances a definite danger to the patient

From a surgical point of view, the first use for this type of tube would be in the severe types of postoperative distention and ileus. The milder types of distentio postoperatively have been shown to be due to ingested air,[9] and can easily be relieved by withholding food for several days or by the use of a Levin tube and suction. However, the severe forms of postoperative intestinal distention and those cases of ileus which are due to intra-abdominal infection definitely require the long intestinal tube. In this type of case, the use of the tube can be a life saving measure, providing the surgeon is certain that the patient is not suffering from postoperative intestinal obstruction instead of ileus. Here, the brain of the surgeon and not the tube may save or lose the patient. Sometimes the differentiation is difficult to make, but if effective intestinal decompression is carried out and the abdomen becomes flat but a knuckle of bowel is obstructed by adhesive bands or by passing through a rent in the broad ligament or omentum, obviously such a decompressed bowel merely lulls the surgeon into a false sense of security while the obstruction goes on and inevitably produces strangulation and perforation of the bowel. The use of the tube in post-

Fig. 4. Marked distention of the intestinal tract.

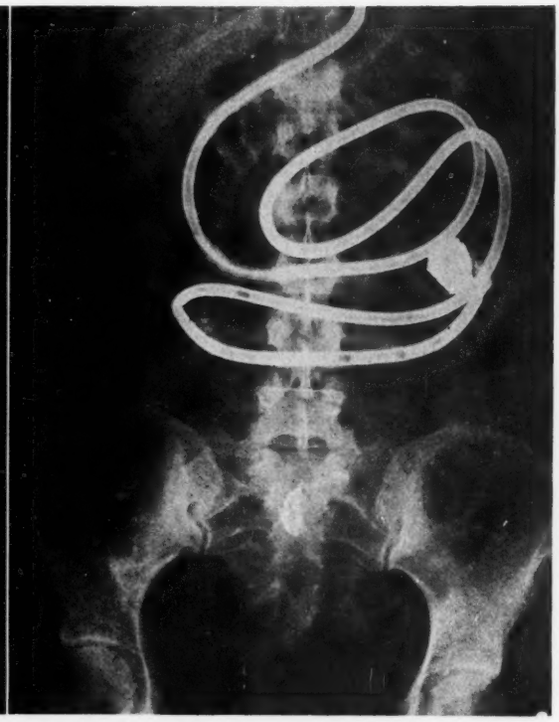


Fig. 5. Marked decrease in intestinal distention. The tube "head" is well down the intestinal tract. The tube is visualized so well that even the holes in the tube stand out.

operative ileus due to pelvic peritonitis or general peritonitis, or in cases of ileus due to a small pocket of pus in the pelvis following surgery constitutes the type of case in which the results of intestinal intubation are most brilliant, but the use of the long tube therapeutically in intestinal obstruction is exceedingly dangerous.

Case III. C. B., a thirty-seven year old white woman was admitted to Grace Hospital on July 11, 1946, with a diagnosis of intestinal obstruction. On examination, her abdomen was found to be markedly distended. She had been vomiting for one week, and had passed no gas per rectum. A flat plate taken on July 13, 1946, (Fig. 4) revealed a dilated jejunum and ileum indicating intestinal obstruction probably at the level of the ileum. A Cantor tube was passed. Check films taken twenty-four hours later revealed the tip of the tube to be well past the ligament of Treitz in the upper segments of the jejunum. The intestinal inflation had markedly decreased. A forty-eight hour film showed the tube to be in the ileum. (Fig. 5.) There was considerably less inflation in the small bowel than previously noted forty-eight hours ago. The patient was taken to the operating room July 15, 1946. At operation multiple adhesions of the small intestines and ascending colon were found. These were the result of a right salpingectomy which had been done six months previously for ectopic pregnancy. The adhesions producing the obstruction were separated. A sterile abscess was then encountered on the right side between the ascending colon, abdominal wall and small intestines. Much granulation tissue was found on the intestines. The bowel had been completely obstructed by adhesive bands. Recovery postoperatively was uneventful. The patient was discharged on the eleventh postoperative day.

Here we have a case in which two separate and distinct etiological factors were found. Either one of these (abscess or adhesions) could have produced the abdominal distention. If a diagnosis of ileus due to abscess were made, and the patient treated by intubation alone, it should be quite evident that the results would be disasterous.

If the tube is to be used in cases of bowel obstruction, we believe that its only function is to decompress the gastrointestinal tract and so give the surgeon time to study the patient and properly prepare him for

Fig. 6. Marked distention on flat plate of the abdomen.

Fig. 7. Tube down in the intestinal tract. A small amount of barium made it possible to visualize the marked distention well. Note the size of holes in tube which made aspiration simple.

surgery. We cannot subscribe to the idea that many types of non-strangulating intestinal obstruction, non-inflammatory in nature, can be cured by intestinal intubation alone. Although it is true, that if the obstruction is due to an inflammatory exudate, the use of the tube will keep the bowel decompressed until the exudate or inflammatory area producing the obstruction is resolved with a resultant release of the obstruction. This type of case we classify with the inflammatory distention group. Cases of mechanical intestinal obstruction whether due to adhesive bands, internal hernia, tortion of bowel, foreign body in the bowel, tumors of bowel, or in fact any non-inflammatory obstructive lesion should be operated upon. The preliminary use of the long tube for decompression is merely an aid to proper surgical intervention and must not replace surgery.

The long tube can be used very successfully to keep the bowel decompressed preparatory to bowel resection for a known lesion. In this type of case, an end-to-end anastomosis can be done safely with the tube *in situ* above the point of anastomosis, or the tube can be used as a safety valve in many cases in which a Witzel enterostomy would be done. The function of the intestinal decompression tube here would be much like the safety valve enterostomies that are often done to prevent undue strain on the line of anastomosis. In the following case, this technic was used with excellent results:

Case iv C. J., a fifty-one year old white man, was admitted to Grace Hospital on August 8, 1946, with a diagnosis of intestinal obstruction. On examination, he was found to be markedly distended and his abdomen was tender. He had vomited for two days. A Cantor tube was passed. Twenty-four hour roentgen examination showed the tube to be in the jejunum. (Figs. 6 and 7.) The abdominal distention decreased markedly with suction applied to the tube. At operation ten days later, an annular carcinoma of the rectosigmoid producing intestinal obstruction was found. A colostomy was done as a first stage for resection. Convalescence was uneventful and the

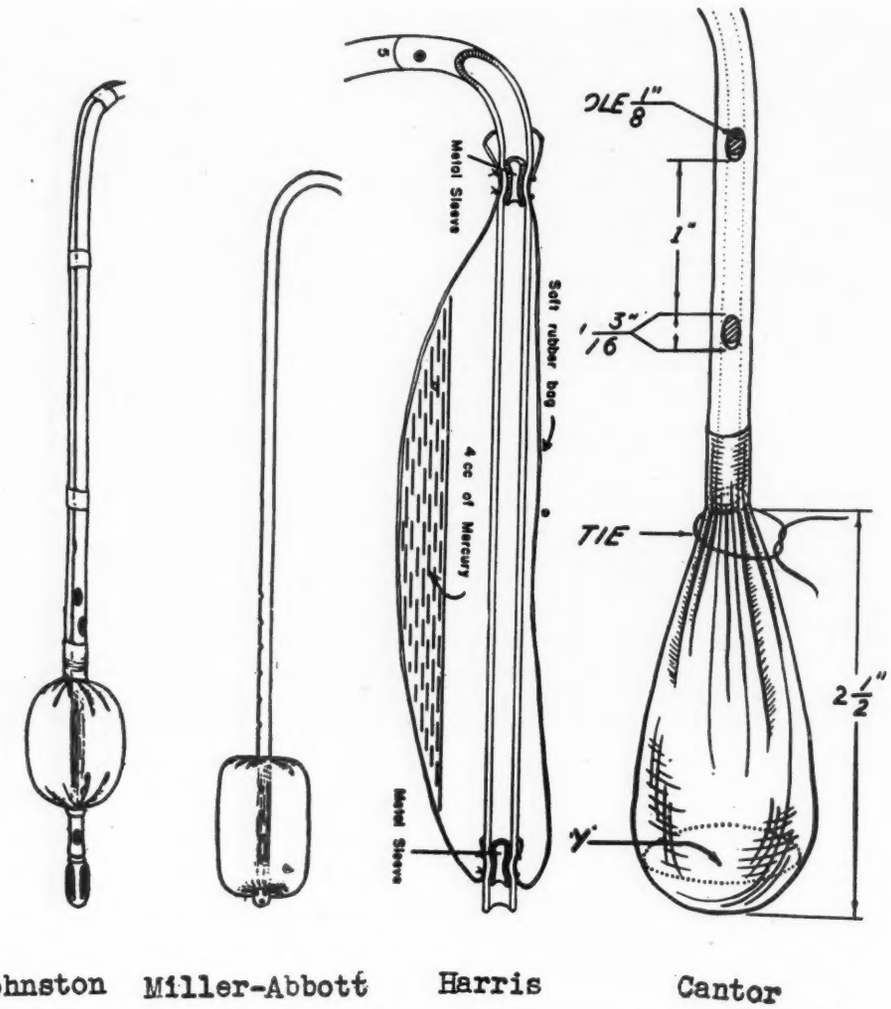


FIG. 8. The "head" of each of the four intestinal decompression tubes in use today. This head constitutes the propulsive mechanism. In only one head is there a radical departure from previous types. Note the complete absence of all metal parts in this tube head.

patient was sent home to return at a later date for resection.

In this case, the long tube carried the patient over the emergency and enabled the surgeon to prepare the patient carefully so that the subsequent surgery could be done with a minimum of effort to the surgeon and risk to the patient.

In the foregoing discussion, it has been assumed that the long tube has been properly passed and that it has moved down into the small bowel. Unfortunately, that is not always the case. The proper passage of the long tube requires a great deal of patience and "know-how." It cannot be relegated to the junior intern or to the nurse on the floor. The experience of our *x*-ray department has been that too often the tube has been passed by someone without the faintest idea of the mechanics involved. The result is failure regardless of the type of tube used. The most common error that we found in passing these tubes is the passage of too much tubing into the stomach without regard to the problems involved in passing the specific tube in question. The surgeon should be familiar with the principle involved in the construction of each type of intestinal decompression tube and the method of passage advocated by the proponents of that tube. Figure 8 shows the different heads on the various intestinal decompression tubes in

use today. The surgeon who developed each tube designed the head of the tube to satisfy certain criteria that he thought necessary in order to get the tube to pass.

A glance at Figure 8 will readily reveal that the Miller-Abbott and Johnston tubes are double lumen tubes with the balloon attached along the shaft of the distal end of the tube, and with a small segment of tube, usually covered by a metal perforated knob, at the very end of the tube. Both these tubes were designed to meet the idea of Miller-Abbott and Johnston that, "it is necessary to decompress the gut in front of the balloon in order for the balloon to then act like a bolus when inflated. In this way the tube is carried down the gastrointestinal tract." The only other difference between the tubes is the fact that in the Miller-Abbott tube the double lumen is inclosed in one sheath whereas in the Johnston tube the lumenal diameter for suction is greater and the tubes are externally attached to each other. Here, then, we have the principle of decompression in front of the balloon and hence the construction of a tube with the power of decompressing in front of the tube. When Harris[10] suggested placing mercury in the balloon of the Miller-Abbott tube in order to facilitate its passage, the design of the original tube remained the same. The result is that the tube is used as a combination mercury and air tube, acting we believe like a "shot-gun" prescription for it embodies the use of two completely different propulsive principles. Harris for several years[11] had also been developing a single lumen mercury weighted intestinal decompression tube in which the mercury alone was placed in the balloon as the sole propulsive agent. However, a glance at Figure 8 shows readily that the placing of the balloon along the shaft of the tube at its distal end was exactly like that of the Miller-Abbott tube with the tip open for suction. Since it should be quite evident that only the distal end of the tube or its "head" constitutes the propulsive mechanism, then the same problems would arise in the passage of the Harris tube as in the mercury weighted Miller-Abbott tube. We do not believe that placing the shaft through the balloon permits the free flow of mercury, and tends to make the "head" so bulky that difficulty often arises in passing it through the nose. The Cantor tube was designed to permit the utilization of all the physical properties of mercury to the utmost. For this reason, a loose balloon was placed at the very end of the tube. This is to permit a "free-flow" of mercury in a very loose bag. Because of this "free-flow" and the weight of the mercury the surgeon must maneuver the patient in order to take advantage of this tube design. The complete absence of all metal in the tube and the terminal attachment of the balloon makes it possible to pass this type of tube painlessly even through the narrowest of nasal passages without much discomfort. Figure 9 is a drawing of the type of case in which it was found to be impossible to pass any other type of tube. In order to pass the Cantor

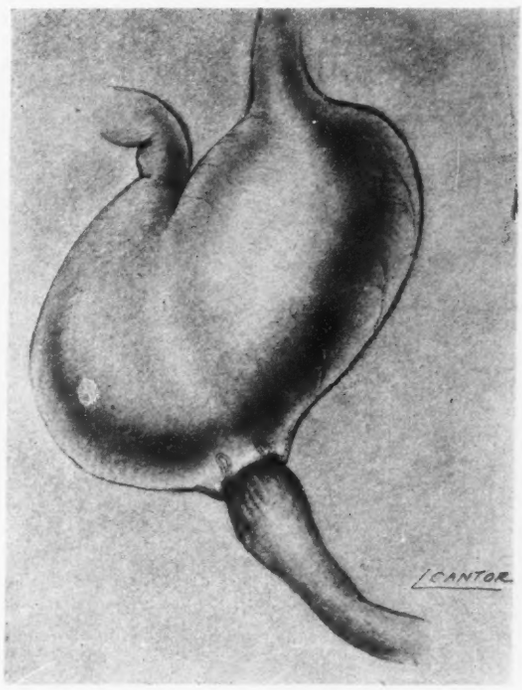


Fig. 9. This patient had had a partial gastrectomy some time previously. Note the stoma position. Turning this patient on his left side would make passage of mercury weighted tube impossible as it would pass into proximal loop.

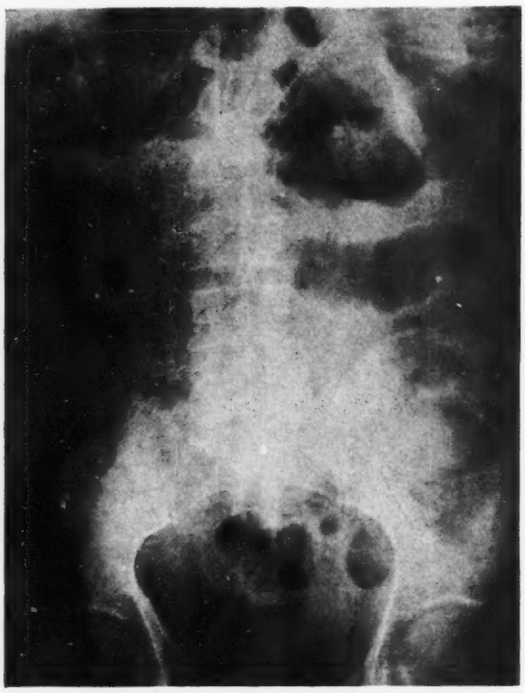


Fig. 10. Tremendous amount of distention (portable film).

tube here, it was found to be necessary to increase the amount of mercury to 8 cc. and to stand the patient up in order to get the effect of a dilating wedge against the stoma. It is the same mechanism as that seen by the bag of waters in dilating the cervix during labor.

Although we are making an effort to standardize the technic of passing the long mercury weighted intestinal decompression tube in order to facilitate its passage through the pylorus and so into the small intestine, it must be borne in mind that each case is somewhat different and slight variations in technic are necessary in order to insure success.

The illness of the patient is an important consideration. A critically ill, dehydrated, weak patient must be treated much differently from a robust man who is chronically obstructed. It may not be possible for the patient to co-operate in the passage of the tube, or the intestinal tone of the patient may be so poor that the peristaltic activity of the bowel as an aide to the passage of the tube is entirely absent. Here we would necessarily have to rely upon the physical properties of the mercury to secure passage of the tube. That is, the effect of gravity and motion upon a loose balloon-tipped tube weighted with freely movable mercury. The physical properties of mercury, i.e., its weight and lability and the effect of gravity would have to be used to the utmost. For this reason, changes in position of the patient (early ambulation and motion) are most important.

Case v. I. A., a seventy year old white man, was admitted to Grace Hospital with a diagnosis of ileus. On examination, his abdomen was found to be markedly distended. There was marked tenderness over the descending colon. Temperature, pulse and respiration were normal. White blood count and differential were also normal. Sigmoidoscopic examination revealed no pathological condition. Because of the marked distention a Cantor tube was passed. A twenty-four hour survey revealed the tube to be down into the distal jejunum. The abdomen was considerably softer and flatter. Two days later a small amount of barium was injected through the tube into the small bowel. (Figs. 10, 11, 12.) Series studies were made which showed a cherry-sized diverticulum in the proximal jejunal loop in the midportion of the left abdominal cavity. The barium was seen to pass into the proximal portion of the transverse colon. No obstructive process was demonstrated. Fluoroscopic examination of the large bowel during and following the administration of a barium enema revealed normal colonic size, position and configuration. Roentgenograms obtained before and after evacuation showed no evidence of disease in the large bowel. His abdomen gradually became soft and flat. He passed a soft stool on the fourth and fifth days. The tube was removed. He was up in a chair. Three days later he suddenly complained of pain in the chest radiating down the arms. He presented all the clinical findings of severe coronary occlusion and died.

Here we find a case of severe adynamic ileus in which the intestinal distention was properly treated by the use of a Cantor tube. Leaving the tube *in situ*, it was possible to carry out *x*-ray studies of the bowel without danger. At the first indication of obstruction, it would have been possible to aspirate the excess barium through the

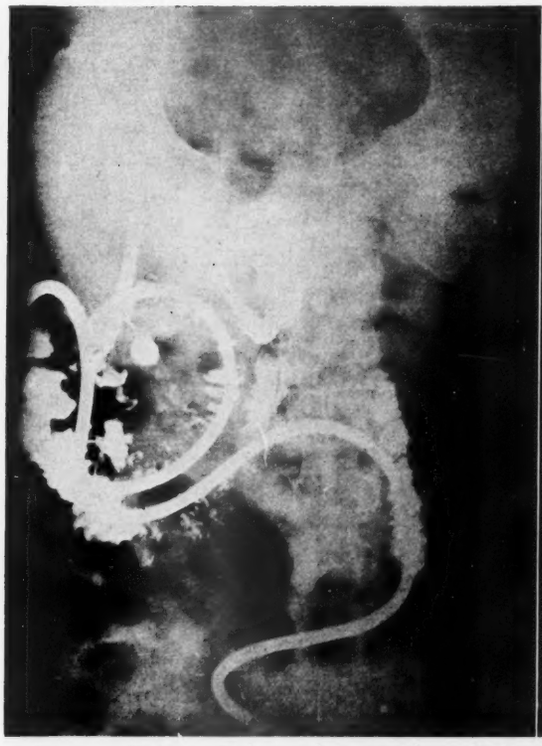


Fig. 11. Tube well down the gastrointestinal tract. A small amount of very liquid barium has been injected. Note decrease in amount of distention.

Fig. 12. Note the absence of all barium from the small bowel, and its presence in cecum and ascending colon. There is a great decrease in intestinal distention.

tube. The use of the tube here makes possible roentgen studies in this type of ileus which might otherwise have been very dangerous.

It must be realized that in any of the channels through which the tube must pass to get into the jejunum, that there may be barriers to its passage. These can usually be overcome by a judicious mixture of common sense, a knowledge of anatomy and various drugs that we have in our armamentarium. The nose, the cardiac sphincter of the stomach, the pyloric sphincter, the ascending limb of the duodenum, the posterior position of the pouch of the fundus of the stomach, all these require some maneuver to prevent trapping any mercury weighted tube. Remember always, that a free flow of mercury and gravity carries the tube downward and that peristaltic activity may or may not aid. A mercury weighted tube will run uphill, if at all, with great difficulty. Put the patient in such a position, that the mercury weighted head will always run downhill to get to the area into which we want it to go.

The height of the patient is of importance in the passage of the tube. A tall patient with a long thorax will obviously require a greater initial length of tube to reach the pylorus than would a short, fat patient with a high diaphragm. If the same length of tube were used in both cases, the tube that would reach the pylorus of the tall patient would coil up in the stomach of the short one. For a patient of average height, if twenty-four inches of tube is passed first, the balloon should be at the pylorus with enough slack to permit it to pass through. In a short patient less tube should be used.

Before attempting to pass the long intestinal decompression tube, the patient must be given a hypodermic injection of morphine sulfate gr. $\frac{1}{6}$ and atropine sulfate gr. $\frac{1}{150}$. This will allay nervousness in these sick people and tend to relax the cardiac and pyloric sphincters. If this is not done, the extreme nervousness of some

FIG. 13. Tube "head" weighted with mercury comes to lie in fundus of stomach with patient flat on back.

FIG. 14. The "head" of tube trapped in the lower esophagus while a long loop has worked its way well into the stomach.

patients will result in a cardiospasm or pylorospasm effectively blocking the entrance into and the outlet of the stomach so that no tube could pass. Figure 14 exemplifies this type of case. Here we see, the balloon containing the mercury trapped in the lower esophagus while a loop of tube slipped by and passed into the stomach. When this patient was given morphine sulfate gr. ¼ and atropine sulfate gr. 1/100, the mercury weighted balloon dropped into the stomach and from there downward into the jejunum. The value of the two-hour *x*-ray to demonstrate the position of the tube is well shown here. Although the stomach was being effectively decomcompressed, the tube would never have passed downward into the jejunum until the mercury weighted balloon had passed from the esophagus into the stomach.

On several occasions we were consulted by the intern because he found it impossible to get any long tube through the external nares of the patient. The question always arose whether to pass the tube through the mouth. In all the cases that we saw, it was emphasized that a preliminary examination of the external nares is imperative. All these cases presented some nasal pathological condition. In two cases, the turbinates were tremendously enlarged by chronic sinusitis. The application of a 2 per cent ephedrine solution to the nasal mucosa effectively shrunk the turbinates and permitted the passage of the soft compressible head of the Cantor tube with ease. In one case, the septum was markedly deviated to the right. All that was required here was to pass the tube through the left side. One case presented nasal polypi. Here a solution of ephedrine and pontocaine resulted in an easily passed tube.

Elevating the foot of the bed twelve inches and turning the patient on his right side will usually cause the mercury in the balloon tipped tube to run down to the apex of the stomach (pylorus) and so drag the tube after it. If the patient lies on his back, it must be remembered the fundus of the stomach lies in a pouch in the left paravertebral gutter posterior to the antral portion of the stomach. The weight of the

mercury in the balloon head would keep the tube head in the fundus as long as the patient lay in this position. Figure 13 demonstrates well that the heavily weighted head of the tube does not drop to the antrum when the patient lies flat on his back, but always lies in the fundus because of its posterior position. Just how long the patient must lie on his right side and inclined toward his face in order for the balloon-tipped tube to pass through the pylorus varies with the amount of mercury in the balloon, the presence or absence of peristaltic waves in the stomach, the tonus of the stomach and finally the ability of the patient to tolerate the position. Generally an increase in the amount of mercury in the tube head results in an increase in the speed of its passage through the pylorus. This is particularly true in cases in which the tonus of the stomach is poor or in robust people in whom we wish to have the weight of the mercury exert a greater push. In the vast majority of cases, at the end of two hours the tube will have passed into the duodenum. For this reason, we permit these people to lie in this position for two hours.

At the end of the first two hours, we lower the foot of the bed and put the patient up on a backrest in order to take advantage of the effect of gravity on the weighted head in inducing its passage downward along the descending limb of the duodenum. We pass four inches more of tube every two hours. We do not push the tube down, but rely upon the constrictors of the pharynx to carry it down while the patient drinks water. In this way, kinking of the tube is avoided. If the tube is held in the palm of the hand loosely and the patient drinks water, the tube will be seen to pass downward with each swallow.

The third and last maneuver is to leave the patient upon the high backrest and turn him on his left side to secure passage through the third portion of the duodenum across the abdomen. From this point on, moving the patient about and changes of position usually cause the tube to pass well

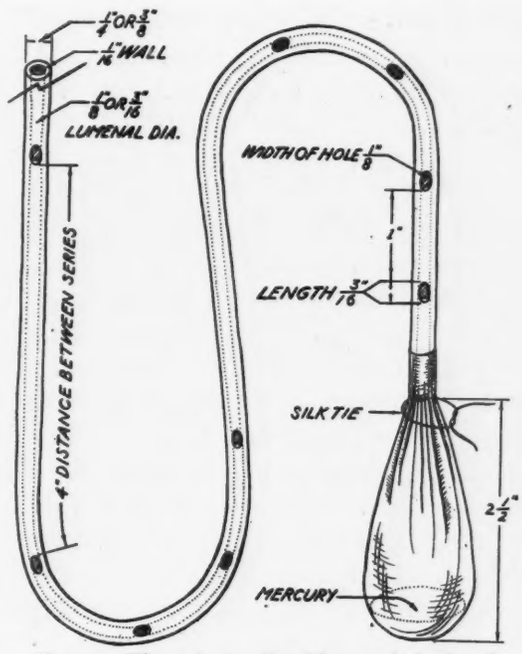


Fig. 15. The tube is all rubber and the head is very thin, highly pliable rubber. There are no metal parts whatever so that tube is compressible enough to pass easily through the narrowest channels. The tube must be tied off at the neck of sac before using in order to prevent leakage of mercury. Note the larger caliber of lumen of tube and of holes for decompression.

down the gastrointestinal tract. In only eight cases were we unable to pass the tube into the jejunum. At no time do we push the tube down into the patient, but rather do we rely upon the swallowing of the patient and the effect of motion and gravity to pass the tube. For this reason, the tube must not be fastened to the face of the patient. Permitting it to lie free, insures its passage downward unaided when peristaltic activity is re-established.

The surgeon should not depend blindly upon the suction device to decompress the patient adequately. Frequent and repeated checks should be made to be sure that the suction is properly connected and functioning. This is particularly true if the Wangensteen bottle method of suction is used. This should not be the function of the nurse. No matter how far the tube progresses into the patient, poor suction spells poor results.

Correction of the distention is only one phase of the treatment. Restoration of the

fluid balance and electrolytes as well as vitamin requirements is of the greatest importance if a favorable outcome is to be expected.

SUMMARY

By using a single lumen long intestinal decompression tube[12] with a mercury weighted balloon tipped head, (Fig. 15), we have been able to intubate successfully 96 per cent of two hundred cases of intestinal distention. The eight failures we believe to be due to a failure to appreciate certain fundamental principles as noted in this paper. The surgeon alone must be responsible for the passage and progress of any intestinal decompression tube if it is to serve the function adequately for which it was designed. It is just as important to pass the long tube properly and adequately decompress the distended abdomen as it is to open that abdomen.

It must be realized that the intestinal decompression tube is merely an instrument and must be used as such by the surgeon and not be relegated to the intern or nurse.

Intestinal decompression tubes should be used only as an adjunct to surgery in cases of bowel obstruction and must not replace surgery. We classify our cases of intestinal obstruction into four groups for purposes of intestinal intubation. These groups are:

Group 1. All cases of ileus due to atony of the bowel, or adynamic and dynamic. All cases in which the obstruction is not in any way mechanical. In this group we use intubation alone.

Group 2. All cases of ileus due to inflammatory lesions. In this group would fall all cases of ileus due to general peritonitis, local peritonitis, plastic exudate, inflammatory masses and any inflammatory process capable of causing ileus. In this group intubation alone may be used until all evidence of acute inflammatory reaction has subsided. Most of these patients do not require surgery, although some will be complicated by adhesive bands and must be operated upon before they are well.

Group 3. All cases of ileus due to mechanical lesions. These vary from mesenteric thrombosis to carcinoma of the rectosigmoid. All these must be operated upon. Intubation aids in making the working field much easier by collapsing the small bowel. Intubation also gives the surgeon time to prepare the patient properly for surgery and so improves the risk to the patient.

Group 4. Patients subjected to selective operations or who would ordinarily have an enterostomy preparatory to anastomosis of bowel or resection. Intestinal intubation obviates the necessity for enterostomy in this type of case.

Intestinal intubation should be intrusted only to one who understands the mechanism involved in the passage of the tube and who is willing to spend the time with the patient to insure proper passag . A long intestinal tube in the hands of the novice is indeed a most dangerous instrument.

CONCLUSIONS

1. The "head" of the long intestinal decompression tube constitutes the propulsive mechanism.

2. A ballon tipped mercury weighted single lumen tube is by far the most efficient instrument to produce intestinal compression.

3. The only cases in which intestinal intubation alone can be safely used are cases of adynamic ileus or cases in the inflammatory distention group.

4. The use of the long intestinal decompression tube as a preliminary to bowel resection or anastomosis obviates the necessity for enterostomy and hence reduces the risk to the patient.

5. The long intestinal decompression tube in the hands of a novice is a very dangerous instrument.

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I should like to express my appreciation to the Clay-Adams Company of New York for manufacturing these tubes and for furnishing them to me gratis for this study.

WOUNDS OF THE COLON AND RECTUM

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WOUNDS of the large intestine and rectum are most serious as far as war wounds are concerned. Mortality with wounds of the large intestine and rectum will be relatively low in our soldiers, mainly because of our means for controlling shock and infection, the good nutrition of our soldiers and the fact that early surgery is performed.

Wounds of the colon constituted 22 per cent of all intra-abdominal visceral injuries in the American Forces in World War 1. It is often the only part of the alimentary tract injured. Wounds of the rectum were relatively infrequent. They constituted only 2.4 per cent of the lesions of the abdominal viscera in World War 1. Lesions often associated with rectal wounds are those of the bladder, the pelvic colon and less frequently, injuries of the small bowel.

Uncomplicated perforations of the large intestine which are caused by a single small missile, when associated with only slight spillage of semisolid fecal material, are attended by a relatively low mortality if early closure of the perforation is performed. Large perforations are usually followed by rapidly developing sepsis, and many of the patients with such injuries die within a few hours. In World War 1, the mortality record for wounds of the large intestine was 58.7 per cent, compared with a mortality of 65.6 per cent following wounds of the small intestine. However, the British quote statistics with a higher mortality for colon injuries, than for small bowel injuries. In World War 1, the death rate following colonic injuries was greatly increased by the group of cases in which colostomy was performed, the mortality after suture of the colon being only slightly more than 50 per cent, while that following colostomy was 75.5 per cent. This does not mean that colostomy is necessarily a dangerous operation but that the sepsis is likely to cause death in cases in which colostomy is required.

The mortality following wounds of the rectum in World War 1, was 45.19 per cent. Death was usually due to rapidly advancing sepsis in the retroperitoneal tissues, or to spreading peritonitis.

WOUNDS OF COLON AND SMALL BOWEL

Wounds of the large intestine may resemble those of the small bowel. (Fig. 1.) A single punctate wound is rarely found in the large and small bowels. Simple transverse wounds are rare but are more often found than punctate wounds. Closely situated punctate wounds of the colon may be exteriorized or may be made to communicate, closed as a single wound and a proximal colostomy made. Multiple wounds may be closed individually. A wound which almost transects the colon may be exteriorized, or treated by suturing or resection and a proximal colostomy made. Multiple lacerated and punctate wounds require resection when separate closure of the perforations is not feasible. The serosa and muscularis may be stripped back from the mucosa as the mesentery is torn away. With a rupture of the muscular coat, ulceration of the mucous membrane may occur. This latter complication may occur within a few hours after wounding. With the rupture of the muscular coat, the blood supply to the mucous membrane is cut off. This may be due to the sudden impact of a projectile on a sac filled with gas or a projectile may exert a dragging effect through strands of fibrous tissue. These ulcerations of the mucosa are likely to be due to air and water blast and probably account for some of the fistulas which form in cases in which the colon was

thought to have escaped injury. A hematoma of the mesentery may hide a perforation of the bowel. Wounds of the mesentery may be accompanied by thrombosis of the mesenteric blood vessels and infarction of the bowel.

Types of Injury to Colon. Wounds of the large intestine may differ from wounds of the small intestine. Because of the lack of numerous coils, perforating wounds of the colon are less often multiple than those of the small bowel. Multiple lesions when found, usually involve the redundant pelvic colon or the flexures. Some small perforations may be caused by minute spicules of pelvic bone and are much more difficult to recognize than are the injuries caused directly by missiles. The large size of the colon leads to a preponderance of tears or perforations Some of the wounds are large and ragged. Complete division of the bowel may occur, but it is less frequent in the large than in the small intestine. Complete division occurs when the bowel is collapsed, in which state it may be only slightly larger than the small intestine. The transverse, descending, and pelvic portions of the colon are the parts most frequently divided.

Retroperitoneal perforations with consequent fecal leakage and cellulitis present difficulties. These posterior perforations may be overlooked because of their minute size or because a hematoma may make the perforation obscure. Injuries of the ascending and descending portions of the colon, which have no mesenteries, are frequently followed by serious retroperitoneal infection.

Infarction. Infarction is more common in the large bowel than in the small intestine. It may result from wounding or severance of mesenteric blood vessels or it may be due to the tearing away of a segment of bowel from its mesentery.

Types of Injury to Rectum. Wounds of the lumbar region, buttocks, perineum and thighs are often complicated by rectal injuries. Rectal lesions vary in size from small perforations, caused by minute projectiles or fragments of pelvic bone, to extensive lacerations. Digital examination of the rectum may detect a perforation or a spicule of bone which projects into the lumen; in other instances blood on the gloved examining finger may be the only indication of rectal injury. Extraperitoneal wounds of the rectum eventually develop local tenderness and other signs of infection of the perineum.

The rectum may be wounded extraperitoneally, intraperitoneally, or both. Missiles may take a side to side, anteroposterior or semi-vertical course. Beside peritonitis, infection of the perirectal extraperitoneal space is a frequent complication.

The external damage may be very great, with tearing away of a large portion of the gluteal region. The anus and lower portion of the rectum may be completely avulsed or the lumen may be opened on one side only. If the projectile is small, the sphincter may be left intact. There is a danger of gas gangrene in the gluteal muscles with extensive wounds of the buttocks. Wounds involving the sacrum without an opening in the bowel are frequently fatal because of infection of the presacral areolar tissue.

CHARACTER OF LESIONS IN DIFFERENT PARTS OF THE COLON

The Cecum. Lesions of the colon may vary greatly in type. Experience has established the proper surgical procedure.

Injuries of the cecum may be small enough to permit closure. Some are large enough to necessitate resection and anastomosis, or the creation of an artificial anus. An ileocolostomy may be performed occasionally. However, in general, an artificial opening, composed of ileum and colon, has proved undesirable.

CASE REPORTS

The patient was shot by a rifle bullet in action with the enemy. The wound of entry was in the right lower abdomen and the wound of exit was high in the right buttock. (Fig. 2A.) First aid was administered at a Battalion Aid Station where an evisceration of

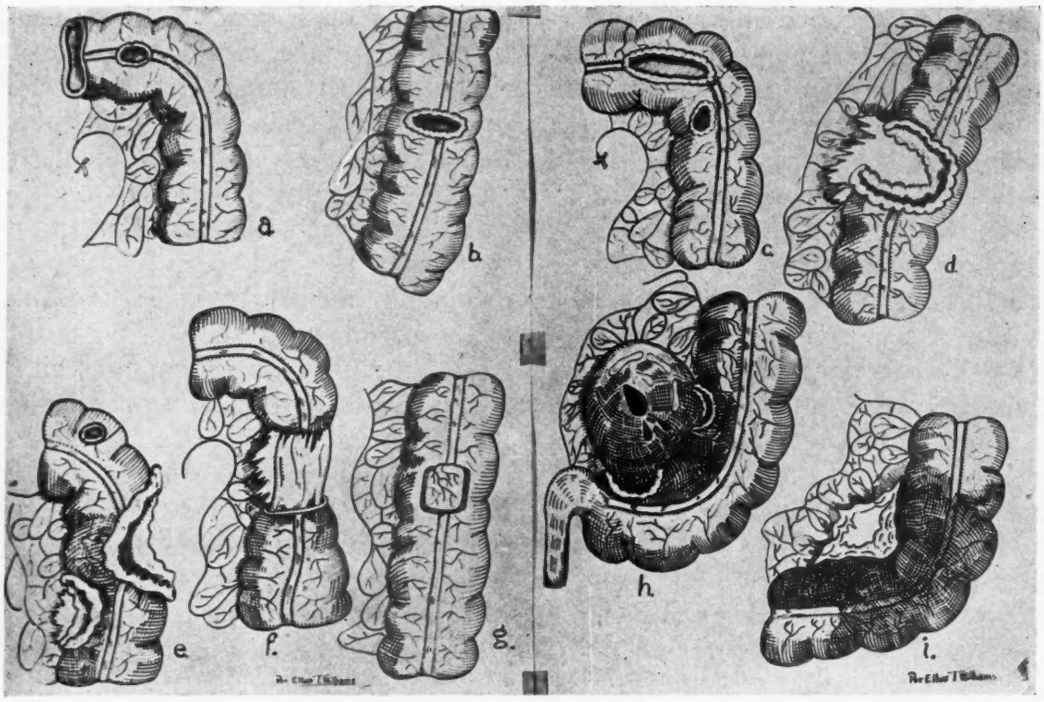
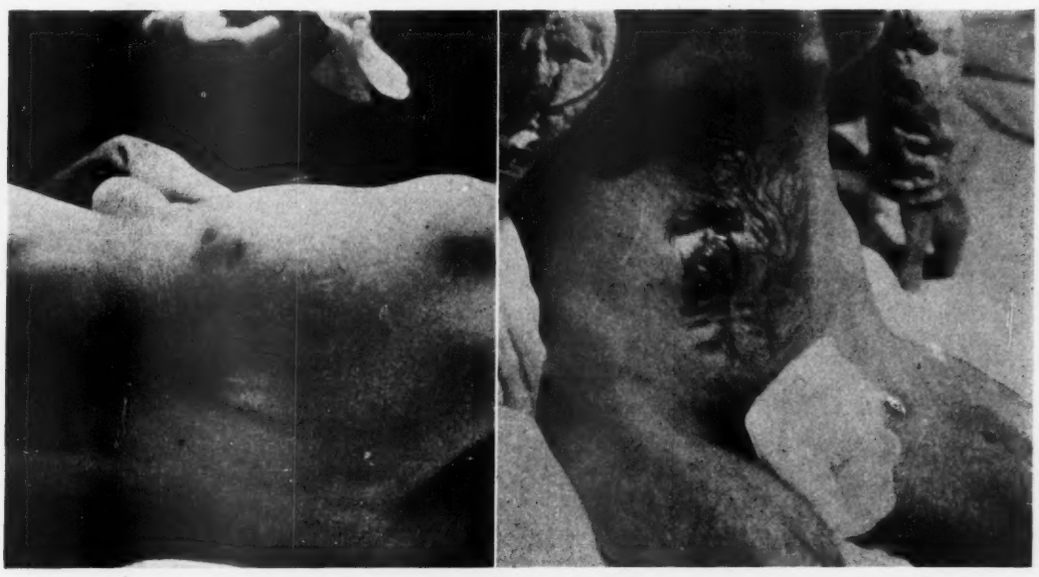


FIG. 1. Various types of injuries of the large intestine. *a*, Single punctate wound; *b*, single transverse laceration; *c*, closely situated lacerated and punctate wounds; *d*, almost complete division of the colon; *e*, multiple lacerated and punctate wounds; *f*, serosa, muscularis and mesentery have been stripped back; *g*, rupture of muscular coat and ulceration of mucous membrane are likely to be caused by air or water blast; *h*, hematoma between leaves of mesentery may hide a wound of the colon; *i*, wound and stripping of the mesentery with damaged blood supply and infarction of wall of colon.

small intestines, through the abdominal wound was found. Wounds were débrided and an exploratory laparotomy was performed at a Field Hospital. Extensive lacerations of the cecum and proximal part of the ascending colon, and a retroperitoneal hematoma were found. A resection of the cecum, appendix and five inches of the ascending colon was performed. A Mikulicz type of colostomy was made with ileum and remnant of the ascending colon. (Fig. 2B.) The colostomy was made in the exploratory wound. The retroperitoneal hematoma was drained through the right lumbar region. There was a moderate maceration of skin and moderate sepsis about the colostomy. The nutritional state of the patient was good. Extensive edema of the colostomy was treated by a firm binder and by having the patient lie in a prone position most of the day. Edema subsided. Five weeks after injury clamps were applied to the colostomy spur and one week later the colostomy was closed. Recovery was uneventful.

In some cases resection may be so extensive that it is not feasible to perform an exteriorization of the bowel. An anastomosis, with a simple proximal colostomy, will suffice.

The patient was shot by a fragment of an 88 mm. shell in action with the enemy. The wound of entry was in the right lower abdomen and the wound of exit was in the right flank. An exploratory laparotomy revealed multiple perforating wounds of the cecum and ascending colon, and a retroperitoneal hematoma. A resection of a small portion of the cecum and the entire ascending colon was performed. An end-to-end anastomosis was made between the end of the cecum and the transverse colon. A simple colostomy was then made in the redundant cecum proximal to the anastomosis. The colostomy was made in the upper part of the exploratory wound. Extensive sepsis developed in the exploratory wound and a moderate amount of maceration developed in the skin about the colostomy. Sepsis was controlled by chemotherapy and wet dressings. The macerated skin healed with aid of zinc oxide ointment. The nutrition of the patient remained good throughout. The colostomy was closed



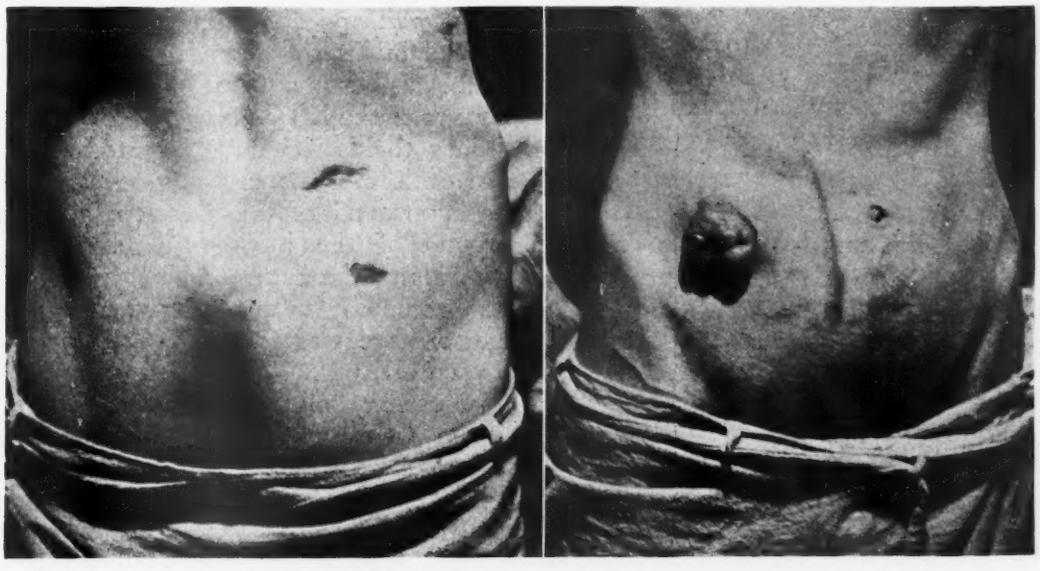
A B

Fig. 2. A, wound of exit high in right buttock; B, ileocolostomy in center of exploratory wound is edematous. There is extensive sepsis of exploratory wound.

eight weeks after injury, by suturing the anterior wall. Recovery was uneventful.

The wounded cecum may be exteriorized as a simple cecostomy or the cecum and proximal part of the ascending colon may be exteriorized as in a Mikulicz type of colostomy.

The patient was shot in the abdomen by fragments from an 88 mm. shell. The wound of entry was in the right lower abdomen. The wound of exit was in the right flank. (Fig. 3A.) An exploratory laparotomy was performed at an Evacuation Hospital. Multiple wounds of the ileum and a large laceration of the cecum extending into the ascending colon were found. A resection of six feet of ileum and anastomosis were performed. A Mikulicz exteriorization of the injured cecum and ascending colon as performed through a stab wound in the right lower quadrant of the abdomen. (Fig. 3B.) The exploratory wound healed without infection and the stab wound through which the colostomy was performed developed no gross sepsis. Bowel function was normal. Recovery was uneventful.



A B

Fig. 3. A, wound of exit in right lumbar region; B, colostomy in a stab wound is edematous. Exploratory wound has healed without sepsis.

FIG. 4. Multiple wounds of the abdomen, due to an explosion of a grenade at close range. Injured colon is exteriorized through a stab wound. Exploratory wound has healed without sepsis.

ASCENDING AND DESCENDING COLON

The ascending and descending portions of the colon may be considered together, as neither has a mesentry. Wounds of these parts of the large intestine may be completely intraperitoneal or extraperitoneal or a combination of the two. The lesions are perforations, splits, tears or complete divisions. Perforations most commonly occur in side to side wounds, and complete divisions in the anteroposterior wounds. Wounds of the ascending colon are of more frequent occurrence than these of the descending colon and the comparative rarity of wounds of the descending colon, observed in the hospital, is probably accounted for by the fact that this part of the colon lies so deep that a missile passing from side to side traverses a coronal plane, situated so far back in the body, as to involve the spinal column and great vessels. In addition, because the descending colon usually is much smaller than the ascending colon, it offers less exposed surface. The intraperitoneal wounds of the vertical colon are usually easily located and dealt with if a suitable incision has been made, but the extraperitoneal wounds, which may be small and valvular, are difficult to find because they lie in a mass of areolar tissue and may be obscured by a hematoma.

In most cases, with retroperitoneal hematoma, the injury to the colon is obvious.

The patient was shot by a pistol bullet in the abdomen, in action with the enemy. The wound of entry was in the right lumbar region and the wound of exit was in the right thigh. An exploratory laparotomy revealed two perforations of the ascending colon just distal to the cecum and a large retroperitoneal hematoma. The hematoma was drained through the wound in the right lumbar region. The injured ascending colon was exteriorized by Mikulicz method after cutting the posterior peritoneum. The colostomy was performed through the exploratory wound. The wound became septic and a partial dehiscence developed. Sepsis of the wound responded to wet dressings. The gaping wound was closed by secondary suture. Four weeks after injury the colostomy spur was clamped and one week later the colostomy was closed. Bowel functions are normal.

Wounds of large mesenteric blood vessels may result in hemorrhage into the peritoneal cavity besides occasionally forming hematomas in the retroperitoneal spaces or between the leaves of the mesentery.

The patient received multiple wounds of his chest wall and abdomen when a grenade exploded in his right hand. (Fig. 4.) His right hand was blown off. The middle, ring and little fingers of the left hand were blown off. Severe injury to his right eye required enucleation. An exploratory laparotomy revealed a perforating wound of the stomach, a perforating wound of the jejunum, twelve perforating wounds of the ileum and two perforations of the ascending colon. A large intraperitoneal hemorrhage was found, due to a tear in a mesenteric vein. This injured vein was ligated. The perforations in the stomach, jejunum and ileum were sutured. The injured ascending colon, close to the hepatic flexure, was exteriorized by the Mikulicz method through a stab wound in the right upper abdomen. Six weeks after injury the colostomy spur was clamped and eight days later the colostomy was closed. It is interesting to note that there

was no gross sepsis of the exploratory wound or of the stab wound. Bowel functions are normal.

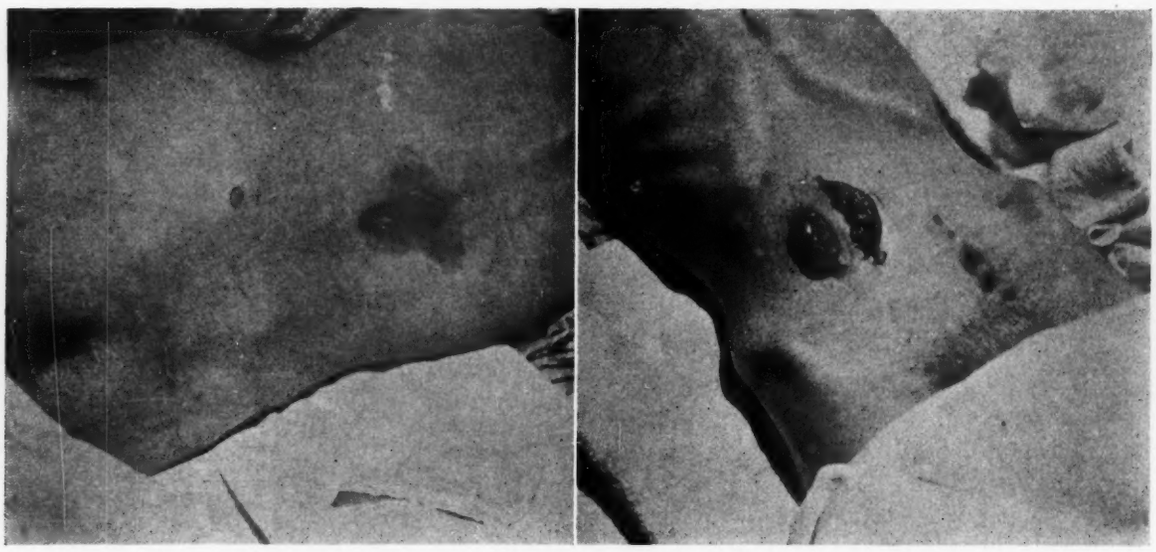
A colostomy must be closely watched at all echelons. Hemorrhage has occurred from some colostomies in transit. A colostomy may retract, even when closely watched, and cause sepsis which may endanger the life of a patient.

The patient was shot in the abdomen by a rifle bullet, in combat with the enemy. The wound of entry was in the right lower abdomen. The wound of exit was in the right lumbar region. There was an evisceration of small and large bowel through the wound in the right lower abdomen. Sulfadiazine was given at the Battalion Aid Station and continued in each echelon. An exploratory laparotomy was performed at an Evacuation Hospital. Perforations were found in the hepatic flexure and in the ascending colon. The wounds in the colon were sutured and a Mikulicz colostomy was performed proximally with the redundant cecum through a stab wound in the right lower abdomen. Four weeks after injury the patient was transferred to a General Hospital. At the time of admission to the General Hospital the patient's temperature was 103°F., pulse was 140 and blood pressure was 100/56. On examination the lateral part of the colostomy was found to have retracted beneath skin, fascia and muscle, so that fecal material was draining retroperitoneally into the lumbar region and pelvis. A clamp was placed on the lateral wall of the colostomy to prevent retraction. Three units of plasma and 2,000 cc. of 10 per cent glucose were given daily for two days. Within twenty-four hours, the patient had recovered from shock and on the following day, under pentothal anesthesia an incision was made in the lumbar region and a cigarette drain was inserted into the pelvis. Organisms cultured from wound were sulfadiazine sensitive. Sulfadiazine therapy was continued. Sepsis gradually subsided. Four weeks after admission to the General Hospital the colostomy spur was clamped and cut, and six days later the colostomy was closed. The patient made a complete recovery.

A complication which has been found to accompany some abdominal wounds is homologous serum jaundice. Homologous serum jaundice is an entity in which investigation is now being conducted, in an attempt to differentiate it from infectious hepatitis. It is so called because it occurs only when human serum, plasma or blood has been used. The etiology is probably a filtrable virus. Irradiation of the contaminated plasma kills the virus. Homologous serum jaundice may gradually subside or the disease may progress to death. In the more serious cases ascites is found. In fatal cases the liver at autopsy, resembles that found in acute yellow atrophy. From present evidence homologous serum jaundice and infectious hepatitis seem to be the same disease, despite attempts made to differentiate them.

The patient was injured by a fragment of an 88 mm. shell. The wound of entry was in the right lower abdomen. The wound of exit was in the right flank. At a Battalion Aid Station the patient was found to be in shock, was given two units of plasma and initial care of his wounds. At an Evacuation Hospital 1,000 cc. of stored blood and two units of plasma were given. At exploratory laparotomy, two penetrating wounds of the ascending colon were found, about three inches distal to the cecum. A Mikulicz type of exteriorization was performed through the exploratory wound. The patient was given sulfadiazine and penicillin therapy and transferred to a General Hospital. The exploratory wound became septic and responded well to wet dressings. Nine weeks after injury clamps were applied to the colostomy spur. One week later, or seventy days after injury, when the colostomy was ready for closure, the patient complained of feeling "grippy." He complained of generalized aches and felt nauseated. Abdominal discomfort and pain were generalized. His temperature was 99.8°F. and pulse was 98. The liver edge was palpable. Four days after onset of symptoms, the patient developed jaundice. Icteric Index was 17. Van den Bergh was indirect with 1.5 units per 100 cc. of serum. The patient was given a high protein diet. Jaundice persisted for seventeen days. This patient later had a closure of his colostomy with no further trouble.

Extraperitoneal wounds of the descending or ascending colon may be difficult to



A B

FIG. 5. A, wound in left lumbar region through which fecal material drained eight days after exploratory laparotomy revealed no injury to the colon. The descending colon was almost surrounded by a retroperitoneal hematoma. B, Devine colostomy was performed eight days after exploratory laparotomy when fecal drainage was discovered in wound of the left lumbar region. The original exploratory wound is healed.

localize and may be missed at laparotomy because the wound may be small or valvular, imbedded in a mass of areolar tissue or obscured by a hematoma. If these wounds are missed at laparotomy, discovered later by fecal drainage or sepsis of the wound, and a proximal colostomy made, the colostomy must not be closed for months or until the wound in the bowel and the sinus tract are healed.

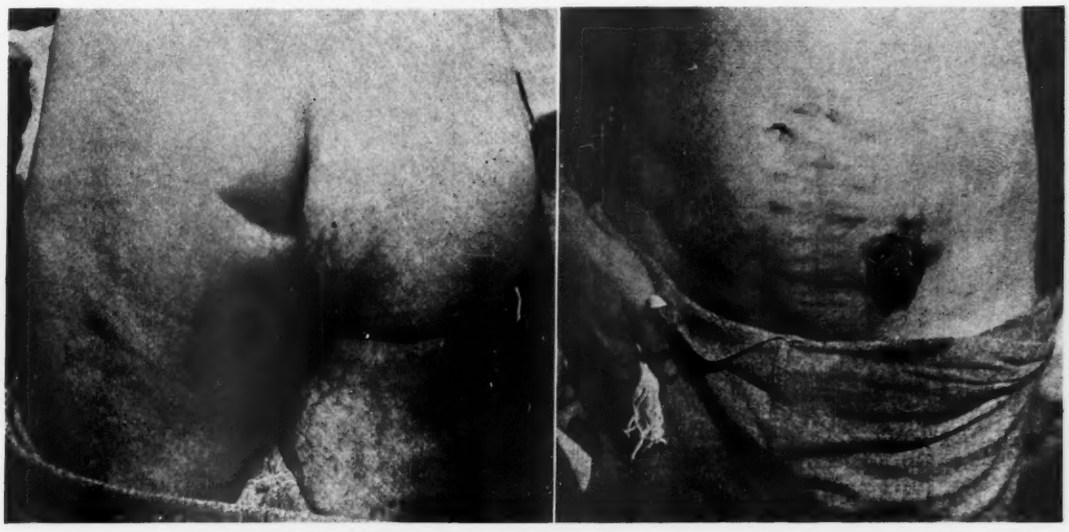
The patient received injuries in the left lumbar region by a fragment of an 88 mm. shell. (Fig. 5A.) There were compound fractures of the left ileum, the left transverse processes of 1, 2, 3 and 4 lumbar vertebrae. Exploratory laparotomy revealed a large retroperitoneal hematoma in the left lumbar region. No wound was found in the small or large bowel. The missile in the lumbar region was removed and the hematoma was drained through the original wound. Eight days after injury fecal drainage was found in the wound in the left lumbar region. A Devine colostomy was made of the right transverse colon. (Fig. 5B.) Thirteen days after colostomy no fecal drainage was found in the lumbar region but a septic discharge was found. Sulfadiazine was continued. No penicillin was used because no penicillin sensitive organisms were found. The colostomy will not be closed for many months or until it can be demonstrated that the wound in the descending colon has healed by barium enema and that no communication exists between the wound in the lumbar region and the descending colon, by lipiodol injection. It will be even safer to wait until the sinus in the left lumbar region has healed. Barium enema will also demonstrate whether a stricture exists at the site of injured colon or not.

Wounds of the buttocks commonly involve the rectum. However, the ascending or descending colon may be involved with wounds of the buttocks.

The patient was shot by a machine gun bullet in action with the enemy. The wound of entry was in the left buttock, (Fig. 6A) and the wound of exit was in the left lower abdomen. Exploratory laparotomy revealed a large tear in the descending colon near the sigmoid. A Mikulicz exteriorization of the injured bowel was performed through a stab wound, after mobilization of the bowel by undercutting the peritoneum. The exploratory wound healed without complication. (Fig. 6B.) Three weeks after injury clamps were applied to the spur of the colostomy and one week later the colostomy was closed.

Large retroperitoneal hematomas may be found with no complicating bowel injury.

The patient was injured by fragments of an 88 mm. shell, in the left chest, left arm, left



A B

Fig. 6. A, wound of entry in left buttock complicated by a wound of the descending colon; B, colostomy in a stab wound is edematous. Edema was easily controlled by a pressure binder and by the patient lying prone.

flank and left buttock. Exploratory laparotomy revealed a large retroperitoneal hematoma involving the entire left lumbar gutter. Inspection revealed no injury to any of the intra-abdominal contents. The hematoma was drained through the wound in the left lumbar region. Adynamic ileus developed, postoperative, and was easily controlled by Miller-Abbott tube. The wound in the left lumbar region healed without complication.

TRANSVERSE COLON

Many types of wounds may involve the transverse colon. True anteroposterior wounds are not very common, since the transverse colon usually is struck obliquely. Wounds of the transverse colon are often accompanied by lesions of the stomach and the small intestine. The posterior surface of this segment of large intestine is sometimes wounded, and injuries in this location are likely to be overlooked. Wounds of the transverse colon are much more easily exteriorized than wounds of the ascending or descending colon. Wounds of the chest may be complicated by wounds of the transverse colon.

The patient was shot in the left chest by a machine gun bullet in action with the enemy. An *x*-ray revealed two bullets in the left chest and a left pneumothorax. There were signs of intraperitoneal injury. An exploratory of the chest was performed, two bullets and fragments of clothing were removed. An exploratory laparotomy revealed two perforating wounds of the transverse colon and a retroperitoneal hematoma of the left lumbar region. A Mikulicz exteriorization of the wounded transverse colon was performed through a stab wound. The retroperitoneal hematoma was drained through an incision in the left lumbar region. Edema of the colostomy was treated by a firm binder and by the patient lying prone. The wound in the left chest healed without complication. The abdominal wounds showed no gross sepsis. Four weeks after injury the colostomy spur was clamped and one week later the colostomy was closed. Bowel function was normal.

Small bowel injury frequently complicates injury to the transverse colon.

The patient was shot in the abdomen by a machine gun bullet, in action with the enemy. The wound of entry was in the left parumbilical region. The wound of exit was in the left loin. An exploratomy revealed two perforating wounds of the ileum and two perforating wounds of the transverse colon. The wounds in the ileum were sutured and the injured transverse colon was exteriorized by the Mikulicz method, through the exploratory left rectus incision. Severe sepsis and partial dehiscence of the exploratory wound developed. (Fig. 7.) Four weeks after injury the colostomy

Fig. 7. Colostomy in the center of exploratory wound. There is extensive sepsis and partial dehiscence of the exploratory wound.

spur was clamped and one week later the colostomy was closed and the dehiscence was repaired.

When exteriorization cannot be performed it may be feasible to suture wounds of the colon and perform a proximal colostomy. Extensive intra-abdominal arterial hemorrhage may be encountered with wounds of the large bowel.

The patient was shot in the abdomen by a machine gun bullet. The wound of entry was in the left parumbilical region and the wound of exit was in the left lumbar region. At exploratory laparotomy, four perforating wounds of the ileum were found and two perforating wounds of the transverse colon. There was an extensive intra-abdominal hemorrhage from a lacerated gastroepiploic artery. The artery was ligated. The wounds of the small bowel were sutured with a single layer of sutures. The wounds of the large bowel were sutured with a double layer of sutures and a colostomy was performed. Eight weeks later barium enema revealed no stricture in the large bowel. The colostomy was closed extraperitoneally.

HEPATIC FLEXURE

The hepatic flexure is usually easy to expose and repair because of its superficial location. Its form makes it susceptible to multiple injuries.

The patient was struck in the abdomen by a fragment of an aerial bomb. The wound of entry was in the right upper abdomen and the

Fig. 8. Colostomy in the center of exploratory wound. Sepsis of exploratory wound and a ventral hernia developed.

wound of exit was in the right flank. At exploratory laparotomy two perforating wounds of the hepatic flexure were found. The injured hepatic flexure was exteriorized by the Mikulicz method. Five weeks after injury the colostomy spur was clamped and nine days later the colostomy was closed.

SPLENIC FLEXURE

Because of its position and fixations, the splenic is the most difficult part of the large intestine to examine and to repair and mobilization of it may be necessary to permit satisfactory inspection or operative procedure. Injuries of the small bowel frequently complicate injuries of the splenic flexure.

The patient was shot in the left lumbar region by a fragment of an 88 mm. shell in action with the enemy. At exploratory laparotomy three perforations of the ileum were found and a perforating wound of the splenic flexure. The wounds of the small bowel were sutured with a single layer of sutures and the wound of the large bowel was sutured with a double layer of sutures. A Mikulicz colostomy of the transverse colon, proximal to the splenic flexure was made. Eight weeks after injury, a barium enema revealed no stricture of the colon. After proper preparation, the colostomy was dis-

sected and an end to end anastomosis performed. Post operative course was uneventful.

SIGMOID

The sigmoid colon is anatomically more like the small intestine than any other part of the colon, and the lesions of the sigmoid colon are somewhat similar to those of the small intestine. There may be slits, perforations, or complete divisions and, next to the injuries of the transverse colon, wounds in this segment of the large intestine are most often complicated by injuries of the small bowel. The frequency of associated fracture of the pelvis increases the gravity of wounds of the pelvic colon. The mobility of the sigmoid usually makes injuries to this part of the bowel amenable to exteriorization.

Peritonitis has been encountered with injuries to the large bowel but has not been accompanied by the high mortality of peritonitis in World War I.

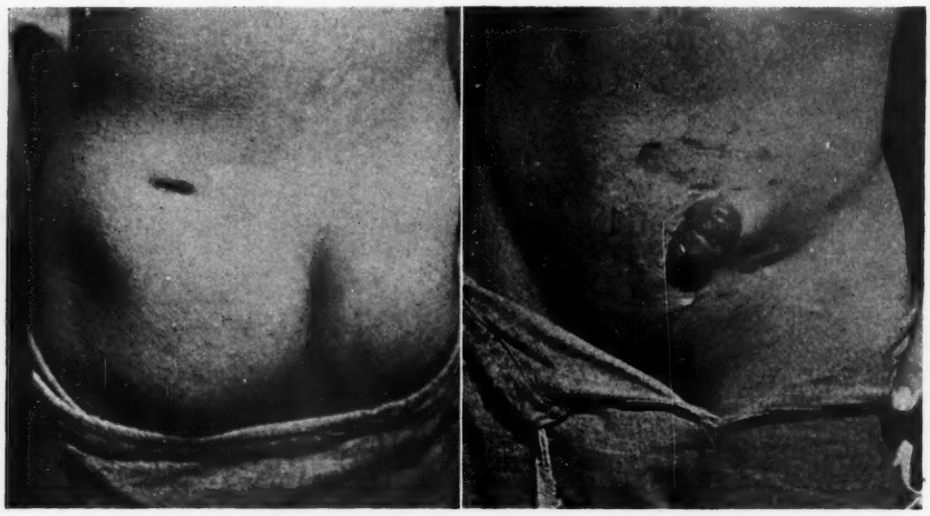
The patient was shot by a machine gun bullet in the left buttock, in action with the enemy. At celiotomy four lacerated wounds of the distal sigmoid were found. One laceration measured two inches long. Fecal contamination of the peritoneal cavity was found. A bullet was removed from the subcuticular region of the right groin. The wounds in the sigmoid were sutured. A Mikulicz colostomy was performed in the sigmoid, proximal to the wounds in the bowel. The patient developed diffuse peritonitis. A culture from the peritoneum revealed hemolytic streptococci, non-hemolytic staplylococci and Bacillus coli. The streptococci were penicillin sensitive. Sulfadiazine and penicillin were given. The patient recovered from general peritonitis without residual abscess. The wound of the buttocks, measured 2 by 2 inches and became septic. The colostomy will not be closed for at least twelve weeks after injury and then only if barium enema shows no perforation and no strieture, and lipiodol injection of the sinus in the left buttock shows no communication with the sigmoid. It will be safer to wait until the sinus tract of the left buttock heals before the colostomy is closed. The colostomy will be closed by dissection and end-to-end anastomosis, intraperitoneally.

Wounds of the sigmoid are very frequently complicated by wounds of the small bowel. Small wounds of the small bowel may be treated by one layer of sutures.

The patient was injured when a fragment of an 88 mm. shell penetrated his left lower abdomen. At celiotomy eight large lacerations in the ileum and six perforations of the distal sigmoid were found. A metallic foreign body was removed from the peritoneal cavity. Two feet of ileum were resected and end-to-end anastomosis performed. The six perforations of the sigmoid were sutured with a double layer of sutures and a Mikulicz colostomy was performed in the sigmoid proximal to the injured sigmoid in the exploratory wound. Sepsis of the wound and a ventral hernia developed. (Fig. 8.) Eight weeks after injury the patient complained of abdominal pain and a "grippy" feeling. The patient was not jaundiced. However, blood studies revealed that he had an icteric index of 11 and indirect Van den Berg of 1 unit per 100 cc. of serum. The patient had received four units of plasma nine weeks previously, and developed a classical picture of homologous serum jaundice. He completely recovered from the homologous serum jaundice in six weeks. The colostomy was then closed by end-to-end anastomosis, and the defect in the abdominal wall was repaired.

The pelvis is frequently fractured with wounds of the sigmoid. This complicates injuries to the sigmoid still further because bony spicules may perforate other parts of the intestinal tract or osteomyelitis may develop.

The patient was injured in combat when a fragment of an 88 mm. shell penetrated his lower abdomen. An *x*-ray revealed a foreign body imbedded in the sacrum. At laparotomy a large hematoma was found in the mesentery of the sigmoid. The adjacent sigmoid was very dark and apparently devitalized. The devitalizated bowel was exteriorized by the Mikulicz method. One month after injury, the foreign body was removed from the sacrum. Pus was found about the missile. Two weeks later there were *x*-ray signs of osteomyelitis of the sacrum. This patient had been given sulfadiazine continuously since first aid treat-



A B

FIG. 9. A, wound of buttock was complicated by wounds of the rectum and urinary bladder; B, sigmoid colostomy proximal to unsutured extraperitoneal wound of the rectum. Cystostomy wound is healed. Colostomy will not be closed for at least six months after injury.

ment. In four weeks all purulent drainage had ceased and two weeks later the wound over the sacrum was healed. Repeated *x*-ray show a healing of osteomyelitis of the sacrum. Eight weeks after injury clamps were applied to the colostomy spur and five days later the colostomy was closed.

Wounds of the sigmoid may be complicated by rents in the mesentery of the sigmoid. This condition may be accompanied by a large hemorrhage.

This patient was injured when a fragment of an 88 mm. shell penetrated his left lower abdomen. At celiotomy a four-inch laceration of his sigmoid, and a rent in the mesentery four inches long and three inches wide were found. A large intra-abdominal hemorrhage was also found. The bleeding vessels in the sigmoid mesentery were ligated. The injured and devitalized sigmoid was exteriorized by the Mickulicz method. The patient recovered from shock with 2,000 cc. of stored blood and two units of plasma. Three weeks after injury the colostomy was closed by end-to-end anastomosis. Recovery was uneventful.

RECTUM

Wounds of the buttocks, thighs and perineum are frequently complicated by wounds of the rectum. Wounds of the rectum are often complicated by wounds of the bladder, the pelvic colon, and less frequently, injuries of the small bowel.

Rectal lesions vary in size from small perforations, caused by minute projectiles or fragments of pelvic bone, to extensive lacerations. It is sometimes possible, by means of digital examination of the rectum, to detect a perforation or a spicule of bone which projects into the lumen; in other instances blood on the gloved examining finger may be the only indication of rectal injury. Eventually local tenderness, along with other evidences of infections of the perineum indicate that there has been an extraperitoneal wound of the rectum.

Injuries to the rectum above the peritoneal diaphragm are frequently complicated by peritonitis. Rectal injuries below the pelvic diaphragm may be complicated by perirectal infections.

The following aspects of rectal wounds must be considered: (1) The external damage may be very great with tearing away of a large portion of the gluteal region. The anus and lower portion of the rectum may be completely avulsed or the lumen may be opened on one side only. If the projectile is small, the sphincter may be left intact. Although even extensive wounds of the buttocks are not necessarily serious, there is a danger of gas gangrene

in the gluteal muscles. Sulfadiazine and penicillin have done much to keep the incidence of gas gangrene low and have also proved of great value as therapeutic agents. (2) The rectum may be injured extraperitoneally, intraperitoneally, or both. Missiles which cause the injuries may take a side to side, anteroposterior or semi-vertical course. The side-to-side wounds are deceptive, their posterior situation suggesting that the missile has missed the bowel.

Wounds involving the sacrum without an opening in the bowel are frequently fatal because of infection of the presacral areolar tissue; however, pieces of shell protruding into the rectum on its posterolateral aspect have been removed and recovery has followed without any further surgical procedure.

Wounds of the buttocks are frequently complicated by injuries to the rectum. With wounds of the rectum which are not sutured and a proximal colostomy is performed, the colostomy must not be closed for six months and then only if the rectal wound has been proven to be healed.

The patient was shot in the right and left buttocks by rifle bullets in action with the enemy. An *x*-ray revealed a bullet anterior to the right sacroiliac joint. No fracture of the sacrum or ileum could be detected. The patient bled from the rectum. Digital examination of the rectum revealed a small wound on the posterior rectal wall at about the middle of the sacrum. A Mikulicz colostomy of sigmoid was performed. No attempt was made to close the small wound in the rectum. The colostomy will not be closed for at least six months after the injury and then only if proctoscopic examination proves the wound in the rectum to be healed.

Wounds of the rectum are frequently complicated by wounds of the urinary bladder. With wounds of the rectum and bladder in which a colostomy has been performed, the colostomy should not be closed for at least six months or until the wounds of the rectum and bladder have been proven to be healed.

The patient received wounds of the left buttock from fragments of an 88 mm. shell. (Fig. 9A.) The patient was found to be draining urine and fecal matter from the wound of the left buttock. An exploratory laparotomy revealed no wound of the rectum, intraperitoneally. A urethral catheter was inserted in the bladder. A double barrel colostomy of the sigmoid was performed. Two days later a suprapubic cystostomy was performed and a wound on the posterior aspect of the bladder was sutured. A foreign body was removed from the bladder. Two weeks later the suprapubic catheter was removed and a urethral catheter was inserted. Four weeks later the suprapubic wound was healed and the urethral catheter was removed. (Fig. 9B.) The colostomy will not be closed until six months after injury and then only if the wounds of the rectum are proven healed.

Injury to large blood vessels which supply the rectum may result in delayed and intermittent hemorrhage which may prove fatal.

The patient received a wound of his left lumbar region by a fragment of an 88 mm. shell in combat with the enemy. The patient drained urine from his rectum and from the wound in the left lumbar region. An exploratory laparotomy, revealed spillage of fecal material and about one pint of blood in the peritoneal cavity. No bleeding vessel was found. Pelvic diaphragm of peritoneum was lacerated. No wound of intraperitoneal surface of the rectum was found. A Mikulicz colostomy of the sigmoid was performed and a urethral catheter was inserted into the bladder. Two days later a suprapubic cystostomy was performed and a wound on the posterior wall of the bladder was sutured. The patient was given penicillin and sulfadiazine. An *x*-ray revealed a hole in the center of the sacrum and a metallic foreign body just below and medial to the lower border of the acetabulum of the right pelvis. The patient had no further sign of hemorrhage until three and one half weeks after injury when a hemorrhage of about one quart of blood occurred from the rectum. A pectinotomy was performed and the rectum was packed. The packing was inserted from the anus to the colostomy opening. On the following day the patient had signs of meningitis. The spinal fluid examination was that of purulent menin-

gitis. The rectal pack was removed two days after insertion. Two days later a second rectal hemorrhage of about one pint occurred. A bleeding vessel was clamped and ligated high on the posterior wall of the rectum. A small laceration high on the posterior wall of the rectum was sutured. On the following day a third massive rectal hemorrhage of bright red blood occurred. Digital examination revealed a large retrorectal hematoma. Hemorrhage ceased spontaneously. It was evident that the hemorrhage was occurring from the superior hemorrhoidal artery. A decision was made to get the patient in operable condition if possible, with transfusions of whole blood. During the process of transfusion a fourth hemorrhage occurred. An amputation of the rectum with a perineal approach and a ligation of the superior hemorrhoidal artery was performed. The patient succumbed about one hour after operation. A rent in the superior hemorrhoidal artery was demonstrated in the surgical specimen. Autopsy showed a hole in the center of the sacrum; a healing fibrous peritonitis, acute purulent meningitis, a wound of the bladder and large retrorectal hematoma. The rectum and sigmoid were almost surrounded by a hematoma measuring 10 cm. × 5 cm. A probe inserted into the superior hemorrhoidal artery at the promontory of the sacrum passed into the hematoma. The wound in the lumbar region communicated with the hole in the sacrum, the hematoma and the healed wound on the posterior wall of the bladder.

Treatment. Lesions of the large intestine: Experience has proved the best methods of treating injuries of the large intestine. Two general principles are to be followed (1) Exteriorization is performed whenever possible. (2) If exteriorization is not possible, a proximal colostomy and suturing of the bowel, if possible, is performed.

In order to avoid overlooking wounds of that part of the large intestine which lacks a mesentery, the segment in which injury is suspected must be mobilized. The Trendelenburg position facilitates exposure and repair of injuries of the pelvic colon.

In the instance of extraperitoneal wounds which have been found only after mobilization of the colon, even though closure of the wounds in the bowel is possible, it is advisable to shut off the general peritoneal cavity by a line of sutures joining the anterior surface of the bowel to the lateral abdominal wall, and to provide drainage. In the presence of hematomas it is often impossible to determine definitely the absence of colonic injuries. The region of possible injury, therefore, must be freely drained. Some British advocate a colostomy proximal to the possible site of injured vertical colon, under such circumstances. However, it seems more logical to first débride the lumbar wound, evacuate the hematoma, pack the wound if bleeding persists and cannot be reached, then perform a laparotomy, inspect the peritoneal cavity, and if there is damage or suspicion of damage to the retroperitoneal colon, a proximal colostomy should be performed.

Proximal colostomies, to be of benefit, must be complete. It is most useful in the presence of wounds in the left loin, in which sepsis develops late, and in connection with rectal injuries. It may be used in cases in which fecal fistulas develop from colonic wounds.

Wounds of the large intestine should be treated by simple exteriorization of the involved portion whenever possible. The injured bowel is exteriorized as a simple loop colostomy with a glass rod placed beneath the loop to prevent retraction. There is neither skin nor fascia bridge beneath the loop. An adequate opening is made in the bowel for drainage. The posterior wall of the bowel is never transected. When this colostomy is ready for closure, an elliptical incision is made in the skin about the colostomy. Granulations are excised from colostomy edge. The incision is carried through fascia. The colostomy is closed by two layers of sutures. The peritoneum is not entered. The abdominal wall is closed over the colostomy by through and through sutures.

When a colostomy is formed for a wound in the distal colon, the colon should be completely transected and the two ends brought out on the abdominal wall at different sites. The ends should be sepa-

rated by about two inches so that each end may be covered by a separate dressing, and in order that feces may not enter the distal loop. Before re-establishing colonic continuity, both loops should be irrigated daily with saline or a permanganate solution.

For one week before the operation the patient should be given a low residue diet and sulfadiazine. In some cases penicillin may help. At operation both loops of the colostomy should be thoroughly irrigated with soapy water and finally with saline. Both ends of the bowel are mobilized. Colonic continuity is then established by an intraperitoneal end to end anastomosis. Two layers of sutures are used, a Connell stitch of chromic catgut 00 size, and a Cushing serosal layer of fine silk. Peritoneum and transversalis fascia or posterior sheath of the rectus are sutured with chromic catgut size 1. Through-and-through sutures are inserted through skin, anterior sheath of rectus and rectus muscle of each side, and are left untied for four days. The wound is dusted with sulfanilamide powder and a vaseline dressing is applied. Postoperatively, the patient is given intravenous fluids and nothing by mouth for forty-eight hours. Fluids by mouth are given for two days, then low residue foods, and finally a normal diet. Chemotherapy is continued as is indicated.

A Mikulicz colostomy used for exteriorizing an injured bowel or as a colostomy proximal to the injured colon, was frequently used in the early stages of the war. The reasons for discarding the Mikulicz procedure are the incidence of intestinal obstruction, rotation of the colostomy carrying the mesentery between the loops in a small per cent; and because with the two stomata in such proximity, the same dressing covers both openings and feces in the distal loop is a major factor in the persistence of fistulas from the lower colon and rectum to sites about the lumbar region, buttocks, or pelvis. If a Mikulicz procedure has been performed at a forward echelon, the safest method of closure is by mobilization and end to end anastomosis, intraperitoneally. However, in our series of forty cases, eighty per cent were suitable for clamping of the spur, closure of the anterior wall and a plastic repair of the abdominal wall. In closing the colostomy the aim is two-fold: (1) To avoid infection; (2) to restore all layers of abdominal wall over the sutured bowel and thus avoid a hernia. A procedure has been performed which has satisfactorily met these requisites, in all our cases, closed to date. (Fig. 10A.) An elliptical incision is made about the colostomy, for a distance of about 1 cm. from the edge of the bowel. (Fig. 10B.) The incision is carried through skin and fascia of the external oblique or anterior sheath of the rectus. Granulation tissue is excised from the edge of the bowel. (Fig. 10C.) The colostomy is then closed by two layers of sutures, a layer of Connell sutures with chromic gut size 00 and a layer of Cushing sutures with fine silk. (Fig. 10D.) It has been proven that a more satisfactory closure is accomplished if the fascia of the external oblique is incised besides the skin. When the colostomy is closed the wound is irrigated with saline as a precaution against contamination. The deep layer of fascia is bluntly dissected from the underlying peritoneum for a distance of 1 cm. to 2 cm. around the entire wound. This deep layer may be transversalis, transversus fascia, or posterior sheath of the rectus, depending upon the location of the colostomy. A shelf of abdominal wall now exists, beneath which the sutured bowel may be placed. (Fig. 10E.) Silk through-and-through sutures are placed through all layers of abdominal wall down to the peritoneum. The wound is dusted with sulfanilamide crystals. The sutures are untied. However, a decrease in the extent of the gape of the wound may be accomplished by tension on the sutures, as by tying a single loop. (Fig. 10F.) A vaseline gauze dressing is placed on the wound. The wound is not inspected until the fourth day post operative. If the wound is clean at that time it is closed by simply

FIG. 10. A, sigmoid colostomy ready for closure.

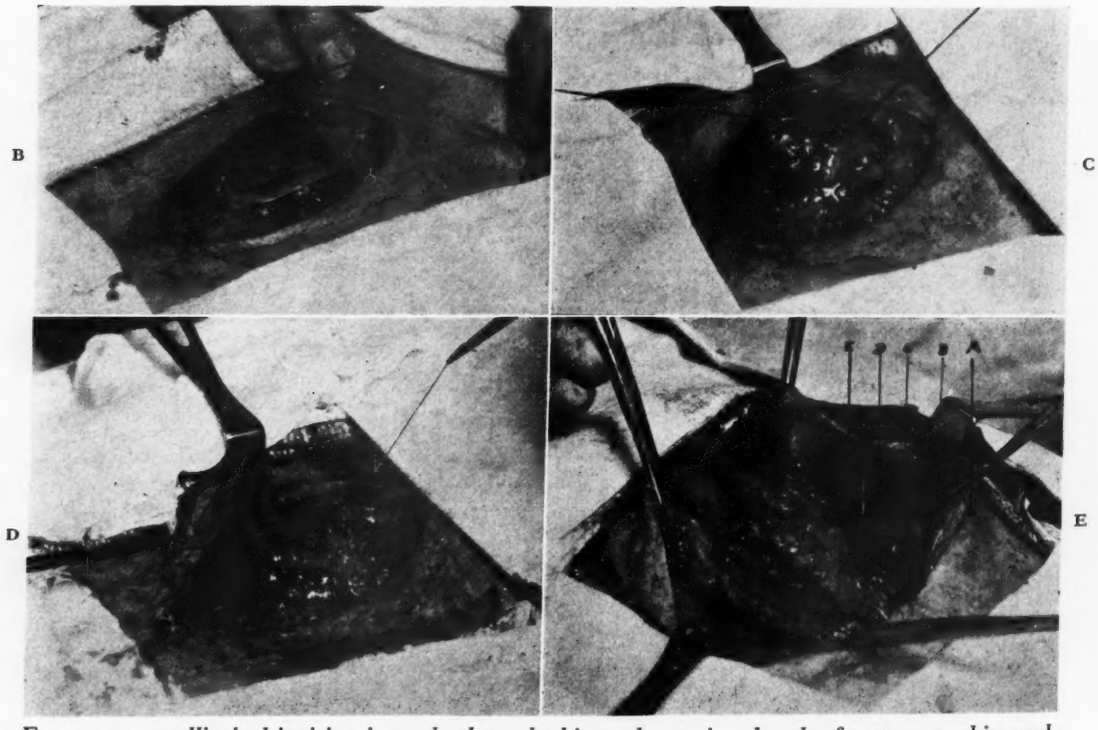


FIG. 10. B, an elliptical incision is made through skin and anterior sheath of rectus; C, skin and scar tissue have been excised from the colostomy edge; D, colostomy has been closed by a double layer of sutures; E, posterior sheath of rectus has been bluntly dissected from peritoneum. A shelf of abdominal wall, fascia-muscle-fascia, 1 to 2 cm. wide is constructed. *A*, skin; *B*, anterior sheath of rectus; *C*, rectus muscle; *D*, posterior sheath of rectus; *E*, peritoneum.

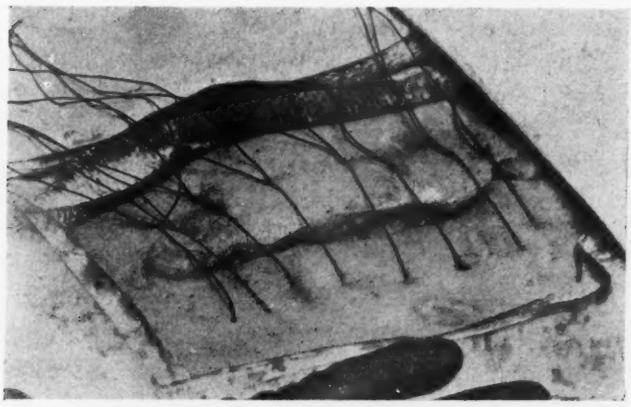


Fig. 10. F, sutures are carried through skin, anterior sheath of rectus, rectus muscle and posterior sheath of rectus on each side. Sutures are united or tied loosely for four days. On the fourth day, if wound is clean, sutures are tied tightly, restoring all layers of abdominal wall over the colostomy.

tying the sutures, under penthothal anesthesia. If the wound is grossly septic after operation, closure of the wound is delayed until sepsis subsides. By this method all layers of abdominal wall, down to peritoneum have been sutured over the closed bowel. Sepsis has been no problem and in no case has a hernia been found post operative.

The Devine colostomy has proved valuable. This procedure avoids all objections to the Mikulicz colostomy. However, it is more time consuming than the Mikulicz procedure. In this operation, the colon is transected, the two loops are sutured along a longitudinal band. The two ends are then brought out through separate stab wounds on either side of the primary incision. A special long-armed spur crusher is used to necrotize the septum. The ends are inverted.

Cecostomy is, in general, of little value. Wounds involving the cecum alone or the cecum and ileum require repair of ileum and cecostomy i.e. exteriorization of the defect. Ileostomy should be avoided and a double-barrelled opening of ileum and cecum has proved to be undesirable.

Gordon-Taylor enumerates the indications for resection.[1] The cecum or colon is in a state of infarction.[2] There is extensive separation of the bowel from its mesocolon or vascular supply, especially if the mesocolon is also the site of a hematoma or is actively bleeding.[3] The vitality of the bowel is extinguished by a large piece of metal or other fragment hurled with the cyclopean force of a modern high explosive.[4] The wound of the large intestine is of such magnitude, or the surgical approach to the part of the colon damaged is associated with such difficulty, as to suggest the formation of an artificial anus as a surgical 'pis aller.' However, exteriorization may be performed in many of these situations.

Drainage is important in the treatment of wounds of the large bowel, and it should be instituted when doubt as to the integrity of the suture line exists, as well as in every case of proved or questionable retroperitoneal injury.

Sulfadiazine is used in all cases. Penicillin may be used when organisms which are penicillin sensitive are found.

Treatment of Injuries of the Rectum. The treatment of rectal injuries associated with wounds of the buttocks, lumbar region or pelvis, consists of excising all damaged tissue and, when possible, closing the rent in the bowel or sphincter, although sometimes it may be better to lay open the lower end of the canal by dividing the sphincter. If the peritoneum has been opened, the abdominal cavity should be closed off by sutures. Proximal colostomy is necessary for all rectal wounds with free

drainage of the perirectal space by incision of the fascia propria. The wound of the rectum may, or may not be sutured. The missle tract in the buttock is never used to drain the retroperitoneal space.

In some cases of rectal injury it is feasible to leave the rectal wound unsutured and to do a proximal colostomy. In such cases it is extremely important to wait about six months or long enough to make certain that the wound in the rectum and the exterior wound have healed, before closing the colostomy.

When a projectile has traversed the pelvis, exploratory laparotomy should be done. If the peritoneal surface of the rectum has escaped injury, the abdomen can be closed and the rectal wound exposed exteriorly. Anterior extraperitoneal wounds of the rectum can be sutured easily, except when they are deep in the pelvis. The bottom of the rectovesical pouch can be shut off by suturing the peritoneum over it.

SUMMARY

The mortality from wounds of the large bowel and rectum will be less in World War II than in World War I, due to the better nutritional state of our soldiers, blood and plasma infusions, chemotherapy and early surgery.

The best method of treating wounds of the colon is by exteriorization, when possible. If exteriorization is not possible, the wounds of the colon should be sutured and a proximal colostomy performed. Resection is rarely indicated.

When colostomy is performed as in exteriorization or as a colostomy proximal to a wound in the distal bowel or as a colostomy proximal to a resected and sutured colon, the colon should be completely transected and the two ends of the bowel brought out on the abdominal wall at different sites. This procedure prevents spillage of fecal material into the distal loop, prevents intestinal obstruction, prevents interposition of a loop of small bowel in a septum, and after proper irrigation of the proximal and distal loops permits end-to-end anastomosis with ease.

Mikulicz colostomy was commonly used in the earlier stages of the war. In our forty cases, one developed intestinal obstruction and in eighty per cent, it was feasible to clamp the spur and close the colostomy. In twenty per cent it was necessary to mobilize the colostomy, dissect the wedge and perform an end-to-end anastomosis, intraperitoneally.

Devine colostomy avoids the difficulties presented by Mikulicz procedure but is more time consuming.

Edema of the colostomy has been frequently met and may be the cause annoying delay in closure of the colostomy. The edema may be satisfactorily treated by reducing the colostomy into the lumen, applying a firm tight abdominal binder, and by having the patient lie prone most of the day.

A colostomy should not be made through the exploratory incision because of the great incidence of sepsis and dehiscence. A separate stab wound is made for a colostomy.

With injuries of the colon and rectum in which the wounds were not sutured and with combined wounds of the rectum and bladder, where a proximal colostomy was performed, a special problem is presented. Before closing the colostomy it is necessary to wait six months or until the wound of the bowel has been proven healed by proctoscopy or barium enema, and to prove that there is no communication between the exterior wound and the lumen of the bowel by lipiodol injection. Otherwise a recurrence of the fecal fistula may be met.

Cases are presented which show how wounds of every part of the colon and rectum and their complications have been handled at different echelons.

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Colostomy usually is *cecal* or *sigmoid;* it is inguinal, lumbar or ventral, according to the location of the new opening which should not be near the anterior iliac spine or umbilicus. Lumbar colostomy, formerly used, is less accessible and more difficult to keep clean, but may be performed without opening the peritoneum by using the extraperitoneal portion of the descending colon.

From "Principles and Practice of Surgery" by W. Wayne Babcock (Lea & Febiger).

MECKEL'S DIVERTICULUM*

REVIEW OF LITERATURE AND ANALYTICAL STUDY OF TWENTY-THREE CASES WITH PARTICULAR EMPHASIS ON BOWEL OBSTRUCTION

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IN spite of the fact that the origin and formation of Meckel's diverticulum has been well known and understood since Meckel's publication on this subject, it is believed that before going into the details of this subject that a brief review of the embryological, the pathological and the histological structures of the anomaly may be of interest and value. The literature on Meckel's diverticulum is very extensive. This interesting congenital anomaly has inspired a number of authors, mainly perhaps because of the serious pathological complications involved in a large percentage (20 per cent) of these cases.

Lichtenstein believes that Hildamus (1598) is probably the first to observe this diverticulum. Lavater reported it in 1671, Ruish in 1707 and Morgagni in 1769. Littre reported a diverticulum in a hernia in 1742. However, Meckel is the first to publish an adequate description of this anomaly and to explain its embryological background. He was the first to associate Meckel's diverticulum with the omphalomesenteric duct. Fabricius tried to explain the formation of Meckel's diverticulum on a mechanical basis. He believed that the pressure of the intestinal content was the probable cause for its formation. The ductus omphalo-entericus or the Vitello-intestinal duct is a slender tube connecting the midgut with the vitelline vesicle or yolk sac during the early weeks of its embryonic life. Persistence of this duct may cause the formation of Meckel's diverticulum in its various forms.

Meckel's diverticulum usually originates from the terminal ileum at its antimesenteric border about 20 inches proximal to the ileocecal valve. McMurrich, Tisdall, Robertson, Reed, Abt and Strauss, however, report cases in which Meckel's diverticulum arose from the mesenteric border and its blood supply passing through an own mesentery to the top of the Meckel's diverticulum (Milese). The distance frequently varies from a few centimeters to 192 cm. and the size from a small intestinal outpouching to a large viscus filling almost half the abdominal cavity (Yates). Giant diverticula are rare, however, we find reports concerning them in the literature by Tisdall, Edmonds, Moll and Edwards. The largest one, according to Yates, filled almost half of the abdomen. The question arises whether this was a true diverticulum of congenital origin or a pseudo diverticulum. Some believe (McMurrish and Tisdall) that these large diverticula are probably the remains of both the ductus omphalo-entericus and the yolk sac.

Hadley reports a case of a nine-year old boy with a Meckel's diverticulum about 3 cm. long originating from the appendix. This was attached to the umbilicus by a vascular band. The mucous membrane was similar to that of the colon. Carlson reports a case of a thirty-eight-weeks old fetus in which two Meckel's diverticula were found, one 50 cm. and the other 70 cm. from the ileocecal valve. Kelly states that Meckel's diverticulum has been found in every portion of the bowel (between the duodenum and the colon). The end of Meckel's diverticulum is usually round, it may also be the seat of knobby secondary diverticula. Christie and Doepf-

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ner reported a case of Meckel's diverticulum bifurcating at the end.

The ductus omphalo-entericus or ductus vitello intestinalis or vitelline duct is a fine tube connecting the vitelline vesicles or yolk sac with the midgut during the early weeks of fetal life. In the eighth or ninth week of fetal life the abdomen will close, so forming the umbilicus. The duct becomes obliterated and separates from the intestine. The fetus is about 7 mm. long at that time. If the vitelline duct remains open at its proximal part, the Meckel's diverticulum results, which usually resembles the ileum in its anatomical and histological structures.

A Meckel's diverticulum may remain attached to the umbilicus or its end may hang free in the abdominal cavity or it may be buried in the mesentery. The free end of the diverticulum may become attached at any point within the abdominal cavity, thereby creating a basis for future bowel obstruction. If the external part of the duct should remain open a small umbilical fistula will usually result, fistula omphalo-enterica incompleta externa. Should the entire ductus omphalo-entericus persist, an intestinal umbilical fistula may form. When the cord is tied off, after the infant is born, the duct will also be tied off and in these cases a fecal fistula will result, fistula enterica completa. Should the mucosa of this fistula prolapse the condition created is known as anus praeternaturalis. Kuestner speaks of diverticulum prolapse, Kermauner of eversion of the mucosa from Meckel's diverticulum.

Another type of a complete intestinal umbilical fistula may develop as follows: Meckel's diverticulum may remain attached to the umbilicus; following infection of the umbilicus, the previous blind end of the diverticulum may perforate and form an anus praeternaturalis; the external and internal ends of the ductus omphalo-entericus may end blind, forming an umbilical cyst, enterocystoma.

Cullen thinks, after studying the reported cases of umbilical polyps, that they are remnants of the omphalomesenteric duct. Anders believes that umbilical tumors may indirectly originate from the ductus omphalo-entericus. If only few (coelom) epithelium persist in the region of the umbilicus, they may become the point of origin for umbilical tumors.

A large percentage of Meckel's diverticula, about 33 per cent, are associated with malformations. This may suggest a primary defect in the germ plasma as a possible etiological factor (Christie).

The obliterated omphalo-entericus duct may form a fibrous cord attached to the umbilicus and ileum and become a cause for bowel obstruction. The fibrous cord may remain attached to the umbilicus or may hang free in the abdominal cavity. It may also become attached to another loop of intestine or to any point of the peritoneum.

According to Kaufman, Meckel's diverticulum is the most common anomaly of the entire intestinal tract. Hilgenreiner and Fehre found one Meckel's diverticulum among fifty to fifty-four autopsies. Kaufman, in a series of 1,600 autopsies revealed about the same percentage. Doepfner finds one in sixty-five autopsies. Anders reveals in a series of 18,330 autopsies only 199 Meckel's diverticula. Curd in 40,439 autopsies 367, an average of only 0.9 per cent; a much lower incidence than that reported by other authors show. Adami 2.7 per cent, Fuchnig 2 per cent and Harbin 2 per cent. Johns Hopkins Hospital reports in 2,600 autopsies fifteen cases of Meckel's diverticulum; Boston City Hospital: 1,382 autopsies eleven cases; Dresden City Hospital: 8,133 autopsies eight cases; and Mitchell, Chicago: 1,635 autopsies thirty-nine cases or 2.25 per cent.

The incidence of Meckel's diverticulum in laparotomies shows similar figures. Balfour reports in 10,000 laparotomies only fifteen cases of Meckel's diverticulum. McGlannan in 14,000 laparotomies only three cases. Others report larger figures. The general estimation is about 2 per cent incidental findings of Meckel's diverticu-

TABLE I

No.	Age	Race	Sex	Preoperative Diagnosis	Postoperative Diagnosis	Pathological Report		Operation	Findings Incidental to Operation	Mortality
						Gross	Microscopic			
1	53	W	M	Bilateral inguinal hernia, incarcerated, right	Same, incarcerated, Meckel's diverticulum in right hernia	Negative	Meckel's diverticulum, lined with regular, small intestinal mucosa	Resection of Meckel's diverticulum, repair of right hernia	Yes	No
2	24	W	M	Recurrent chronic appendicitis	Same, Meckel's diverticulum	Negative	Lined by small intestinal mucosa. Gastric mucosa, pyloric glands chronic inflamed infiltration, no ulceration	Appendectomy Resection of Meckel's diverticulum	Yes	No
3	35	W	M	Recurrent chronic appendicitis	Chronic recurrent appendicitis; Meckel's diverticulum	Meckel's diverticulum with multiple diverticuli, chronic appendicitis	Small intestinal mucosa	Appendectomy Resection of Meckel's diverticulum	Yes	No
4	31	W	F	Acute appendicitis	Acute appendicitis, Meckel's diverticulum	Appendix with fecalith pus mucous retention. Meckel's diverticulum	Small intestinal mucosa in Meckel's diverticulum	Appendectomy Resection of Meckel's diverticulum	Yes	No
5	17	W	F	Acute appendicitis	Subacute appendicitis, Meckel's diverticulum	Same	Small intestinal mucosa in Meckel's diverticulum	Appendectomy Resection of Meckel's diverticulum	Yes	No
6	21	W	M	Acute appendicitis	Recurrent chronic appendicitis; Meckel's diverticulum	Negative	Small intestinal mucosa in Meckel's diverticulum	Appendectomy Resection of Meckel's diverticulum	Yes	No
7	39	W	M	Acute appendicitis	Intestinal obstruction due to persistent omphalo mesenteric vessels, Meckel's diverticulum, chronic recurrent appendicitis	Meckel's diverticulum with marked edema of submucosa	Small intestinal mucosa in Meckel's diverticulum	Releasing obstruction, resection of Meckel's diverticulum; appendectomy	Yes	No
8	31	W	M	Chronic recurrent appendicitis	Acute appendicitis, Meckel's diverticulum	Same, Meckel's diverticulum slightly inflamed	Gastric mucosa	Appendectomy Resection of Meckel's diverticulum	Yes	No
9	54	W	M	Intestinal obstruction	Intestinal obstruction, gangrene of loop of small bowel due to double knotting of free Meckel's diverticulum	Same	No report on mucosa of Meckel's diverticulum	Resection of gangrenous bowel and Meckel's diverticulum	Yes	Died

10	43	W	M	Chronic recurrent appendicitis	Pseudomellanosis of appendix, Meckel's diverticulum	No specimen from Meckel's diverticulum	.....	Inversion of Meckel's diverticulum	Yes	No
11	55	W	M	Chronic recurrent appendicitis	Meckel's diverticulum with slight inflammation	Superficial inflammation of Meckel's diverticulum	Lined by small intestinal mucosa	Appendectomy Resection of Meckel's diverticulum	Yes	No
12	32	W	F	Pelvic inflammatory disease, rectocele	Hematosalpinc, Meckel's diverticulum	Meckel's diverticulum negative	Lined by small intestinal mucosa	Salpingectomy Resection of Meckel's diverticulum	Yes	No
13	14	W	F	Acute appendicitis	Appendix with adhesions at its base; Meckel's diverticulum	Meckel's diverticulum	Small intestinal, mucosa, large lymph follicles	Appendectomy Resection of Meckel's diverticulum	Yes	No
14	41	W	M	Intestinal obstruction	Same, due to Meckel's diverticulum, adherent to umbilicus and persistent omphalo mesenteric vessels	Meckel's diverticulum negative	Lined by gastric and duodenal mucosa	Appendectomy Resection of Meckel's diverticulum releasing obstruction	Yes	No
15	7 mo.	W	M	Incarcerated right inguinal hernia	Meckel's diverticulum strangulated in inguinal hernia	No specimen obtained	.....	Inversion of Meckel's diverticulum	Yes	No
16	77	W	M	Acute appendicitis possible obstruction	Intestinal obstruction due to Meckel's diverticulum with tortion of bowel	Hemorrhagic Meckel's diverticulum	Lined by small intestinal mucosa right in lymphatic tissue	Resection of Meckel's diverticulum	Yes	No
17	13	W	M	Intestinal obstruction	Same, due to Meckel's diverticulum and persistent omphalo mesenteric vessels	Meckel's diverticulum adherent to umbilicus, persistent omphalo mesenteric artery	Small intestinal mucosa	Appendectomy Resection of Meckel's diverticulum and persistent omphalo mesenteric vessels	Yes	No
18	23	W	M	Intestinal obstruction, Meckel's diverticulum	Intestinal obstruction, invaginated Meckel's diverticulum with intussusception	Same, acute hemorrhagic necrosis of Meckel's diverticulum	Small intestinal mucosa	Appendectomy Resection of Meckel's diverticulum and omphalo mesenteric vessels	No	No
19	38	W	M	Subacute appendicitis	Obliterated appendix and Meckel's diverticulum	Same, negative	Lined by small intestinal mucosa	Appendectomy Resection of Meckel's diverticulum	Yes	No
20	22	W	F	Appendicitis, possible pelvic inflammatory disease	Chronic recurrent appendicitis, hemorrhagic, corpus luteum, Meckel's diverticulum	Same	Pancreatic tissue in Meckel's diverticulum	Appendectomy Partial right oophorectomy Resection of Meckel's diverticulum	Yes	No
21	25	W	F	Pelvic inflammatory disease, tubo-ovarian abscess	Same, chronic recurrent, appendicitis, Meckel's diverticulum (hydrosalpinx, etc.)	Same, Meckel's diverticulum negative	Lined by small intestinal mucosa	Bilateral salpingectomy, fundectomy, appendectomy Resection of Meckel's diverticulum	Yes	No

TABLE I (*Continued*)

No.	Age	Race	Sex	Preoperative Diagnosis	Postoperative Diagnosis	Pathological Report		Operation	Findings Incidental to Operation	Mortality
						Gross	Microscopic			
22	8	W	M	Acute appendicitis	Chronic recurrent appendicitis, Meckel's diverticulum	Same, Meckel's diverticulum negative	Small intestinal mucosa	Appendectomy Resection of Meckel's diverticulum	Yes	No
23	26	W	M	Acute appendicitis	Inflammation of Meckel's diverticulum with beginning bowel obstruction	Same	Meckel's diverticulum with gastric mucosa and fresh hemorrhages	Resection of Meckel's diverticulum	Yes	No

lum in laparotomies. However, these figures are inaccurate as only few surgeons make a routine search for Meckel's diverticulum. We see that with slight variations the incidental findings are about 2 per cent.

Age and Sex Incidence. According to Greenwald's analysis of his series there were forty-one in males and four in females (91 per cent in male). Doepfner found it in 214 males and 102 in females. This is twice as frequent in the male, which findings correspond to the reports of most authors. Age varies. The youngest reported in the literature was an infant of three months (Schaetz).

Meckel's diverticulum may be present throughout a lifetime without causing any symptoms, as proved by the incidental autopsy findings. This anomaly, however, will always remain a potential source of danger. Fifteen to 20 per cent (Faust) of all the diverticula are subject to pathological changes.

CLASSIFICATION

Before going into the details of diagnosis and the different types of pathological conditions found in Meckel's diverticulum a classification may help bring these factors to a clearer understanding. Many classifications have been made and advised; however, we believe a modification of the one given by Greenblatt and his associates may be the one of choice.

I. Incidental (without disease, lined by small intestinal, ileum, mucosa)
II. Inflammatory type
  A. Non-specific (due to trauma, foreign bodies, parasites or idiopathic)
    1. Acute
      (a) Catarrhal
      (b) Gangrenous
      (c) With perforation
    2. Subacute
    3. Chronic
  B. Specific
    1. Tuberculosis
    2. Typhoid

TABLE II

No. of Cases	Age		Race		Sex		Preoperative Diagnosis		Postoperative Diagnosis in Regard to Meckel's Diverticulum		Pathological Report			Findings Incidental to Operation	Mortality Per Cent
	Youngest	Oldest	Average	White	Colored	Male	Female				Gross		Microscopic		
256	7 mo.	77 yr.	31.5 yr.	23	..	17	6	Appendicitis	13	Incarcerated Meckel's diverticulum in inguinal hernia	2	Occasional multiple lesions occurring simultaneously			
								Incarcerated hernia	2			Inflammatory Meckel's diverticulum	2	Ileal mucosa	14	21	0.2
								Pelvic inflammatory disease	2	Intestinal obstruction due to Meckel's diverticulum	7	Hemorrhagic Meckel's diverticulum	2	Ilea and gastric mucosa	1		
								Intestinal obstruction	4			Invaginated Meckel's diverticulum	1	Gastric and duodenal mucosa	1		
								Intestinal obstruction and Meckel's diverticulum	1	Inflammatory Meckel's diverticulum	3	Persistent omphalomesenteric vessels	4	Gastric mucosa	3		
								Meckel's diverticulum	1	Invaginated Meckel's diverticulum	1	Double knotting of free Meckel's diverticulum	1	Pancreatic tissue	1		
												Meckel's diverticulum with multiple diverticuli	1	Not recorded	1		
												Meckel's diverticulum adherent to umbilicus	1	No specimen	1		
												Meckel's diverticulum strangulated in inguinal hernia	2				
												Meckel's diverticulum without gross changes	14				

III. Obstructive type
   1. Torsion of volvulus
   2. Intussusception (with diverticulum as the starting point)
   3. Diverticulum knotting around intestine
   4. Bands, remnants of ductus omphalo-entericus and omphalo-entericus vessels
   5. Incarceration in hernia
IV. Peptic ulceration (due to the presence of ectopic gastric tissue)
   1. Ulcer
   2. Penetrating ulcer (with and without hemorrhage)
   3. Perforating ulcer
V. Tumors
   A. Benign
      1. Adenoma
      2. Enterocystoma
      3. Mesodermal tumor
      4. Carcinoid
      5. Myoma
      6. Lipoma
      7. Neuroma
      8. Papilloma
   B. Malignant
      1. Carcinoma
      2. Sarcoma
   C. Heterotopic tissue
      1. Gastric
      2. Pancreatic, etc.

DIAGNOSIS

The correct preoperative diagnosis of Meckel's diverticulum is rarely made. Harbin reports one correct diagnosis out of thirteen cases. The symptoms vary according to the type of Meckel's diverticulum, obstructive, inflammatory or the peptic ulcer type, and are not typical or characteristic. Therefore, the differential diagnosis is difficult. In the differential diagnosis the following pathological conditions should be considered: (1) Acute appendicitis, (2) cholelithiasis, (3) intussusception in young children, (4) diverticulitis of the large bowel, especially sigmoid colon, (5) involvement of appendices epiploicae with torsion and inflammation, (6) acute salpingitis, (7) primary pneumococcic peritonitis, (8) Littre's hernia with obstruction, (9) perforation of ileum (due to foreign bodies) and (10) torsion or strangulation of small bowel with obstruction.

Symptoms of the inflammatory and obstructive type resemble, more or less, those of an inflamed abdominal viscus or a perforative lesion with early partial obstruction.

The onset is usually sudden, pain is early, of colicky character and severe and is localized at first around the umbilicus. Nausea and persistent vomiting are present. Early abdominal distention develops. Tenderness and rigidity is localized in the right or left lower quadrant of the abdomen below the umbilicus.

Halstead describes the shape of the abdomen as an "inverted cone" which he thinks is due to obstruction of the upper part of the intestinal tract. During the early attack the absence of distention of the flanks is conspicuous. The temperature is higher than in appendicitis and toxemia is also more pronounced. A partial or complete obstruction may develop. The most difficult differential diagnosis is probably the one from appendicitis.

Rarely will inflammation develop in a normal Meckel's diverticulum. As a rule there is some predisposing factor present. Meckel's type of diverticulum communicates with the intestine through a rather wide opening. The contents are liquid and the complete muscular coat enables the diverticulum to empty simultaneously with the ileum. This is the main reason why inflammation of Meckel's diverticulum is not as frequent as that of the appendix. It is also, therefore, difficult to visualize Meckel's diverticulum by *x*-ray. Inflammation of Meckel's diverticulum varies from the mild catarrhal to the gangrenous inflammatory type with perforation and peritonitis. The inflammation may be specific, due to tuberculosis or typhoid, or non-specific caused by trauma, parasites, foreign bodies or idiopathy. Borgreve reports foreign bodies in Meckel's diverticulum. Ascaris were seen by Lohr causing spastic ileus.

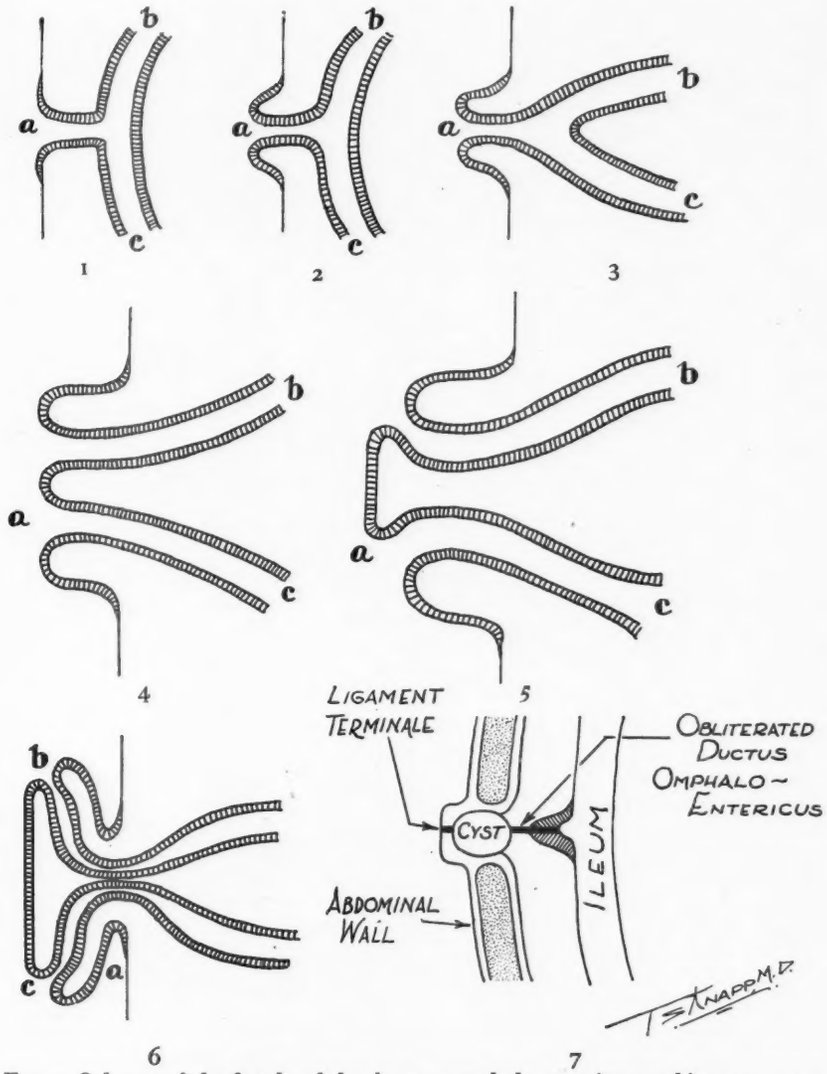

FIG. 1. Scheme of the fistula of the ductus omphalo-entericus and its sequences according to Barth. 1, Scheme of the simple and open Meckel's diverticulum; *a*, originating from the small intestine; *b*, open through the umbilicus to the outside. 2, Onset of the eversion of the diverticulum. 3, Progressive eversion of the diverticulum. The opening is now in the umbilicus. Angular deviation of the afferent and efferent loops of bowel with beginning spur formation. 4, Complete eversion of the diverticulum with accentuated angulation of the loop of bowel and protrusion of the spur. 5, Mushroom type prolapse of the bowel. Afferent and efferent loops ending with separate openings. 6, Similar condition as in 5, however, in progressive stage. 7, Scheme of an umbilical ductus omphalo-entericus cyst.

HETEROTOPIC TISSUE AND ULCER FORMATION

Schaetz revolutionized with his serial studies of thirty diverticula, the entire conception of the histological structure of Meckel's diverticulum. In only 57 per cent the entire mucosa was similar to that of the ileum. Pancreatic tissue and gastric mucosa was shown by 16.6 per cent. One case showed pancreatic tissue, one carcinoid mucosa and one mucosa of undeterminable heteroplasia. Mucosa characteristic of colon was reported by Hudson, Koplic and Stern. Heterotopic tissue occurs in about 25 per cent of cases of Meckel's diverticulum, according to Matt and Fimpone. Farr and Penke try to explain that the heterotopic tissue is a remnant from a primary digestive system during the early weeks of fetal life. Pierre Masson proposes

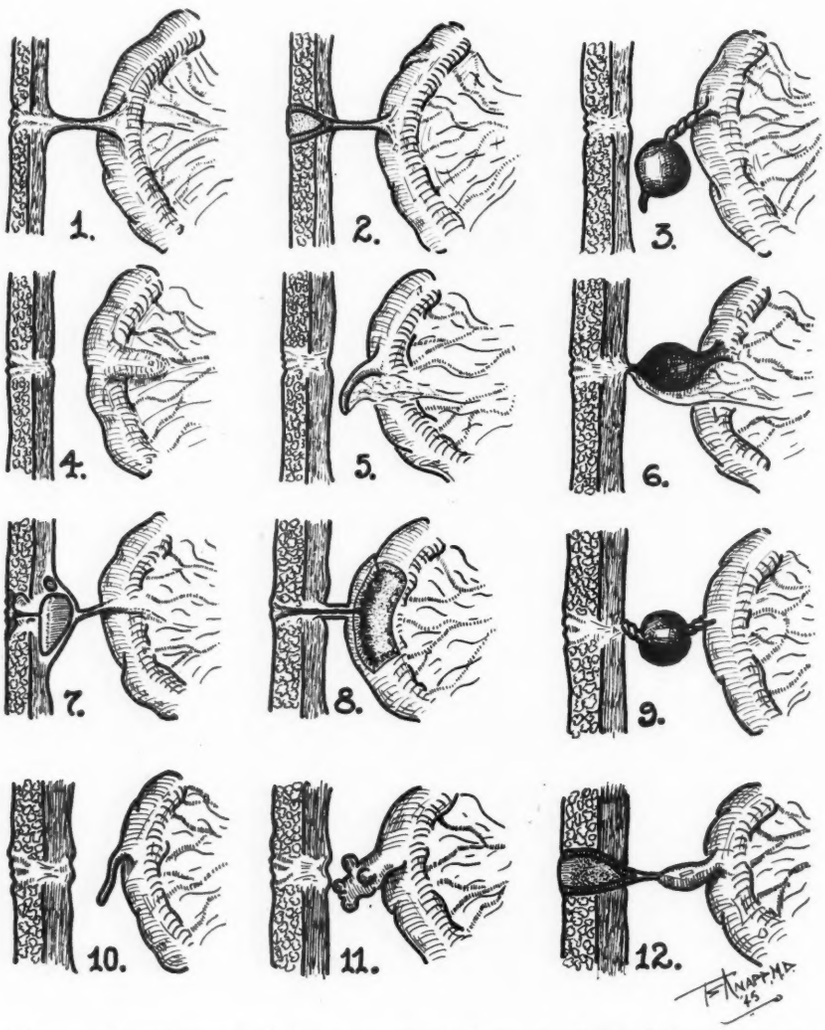

Fig. 2. Diagrams of different anatomical types of Meckel's diverticuli according to Nygaard, Walters and Callender.

his dysembryoma theory and Schaetz his implantation theory.

There are quite a few theories about the development of heterotopic tissue. According to Fishe and Albrecht, the primitive entoderm possesses the ability to develop in any of the types of epithelium or glands from the digestive tract. If stimulated locally it will develop into a tissue anomalous for a particular region.

The gastric mucosa, found occasionally in Meckel's diverticulum, is probably dislocated tissue in the vitelline duct. Zenker, in 1861, was the first who recognized that gastric heterotopic mucosa in Meckel's diverticulum is much more common than pancreatic heterotopia. Kaufman found an accessory pancreas the size of a pea in a three-year old girl. The earliest observation of aberrant gastric mucosa was reported by Tillmann in 1881, found in an umbilical polyp.

Both types of heterotopia may be common in one diverticulum. Gastric heterotopic mucosa may be present in about 15 to 20 per cent (Greenblatt, Rand, Chaney). Similar statistics are collected by Miller and Wallace ninety-three cases, Mason and Graham thirty-three cases, Johnston and Renner seventy-eight cases.

Different types of tumors or tumor tissues may occur occasionally in Meckel's diverticulum. There are only very few cases reported of carcinoid or argentaffin tumors, similar to those found in the appendix (Stewart, Taylor and Price).

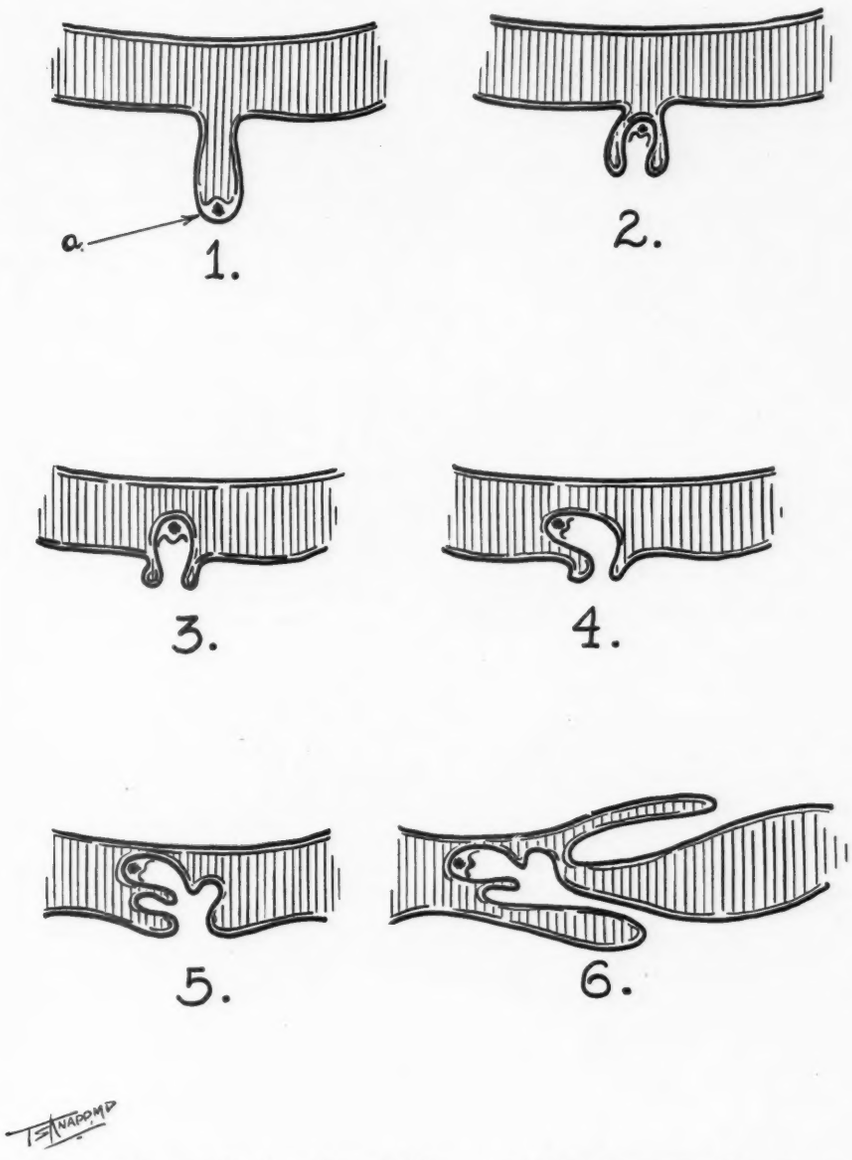

Fig. 3. Diagram showing the probable course of development of the intussusception due to inversion of Meckel's diverticulum according to Edwards.

Brown describes medullary carcinoma, Michael adenocarcinoma in a man of sixty-seven years, Nygaard mentions leiomyoma and sarcoma in a sixty-two-year old patient. A spindle celled sarcoma in a sixty-year old man was found by Liccione. Starling describes a very unusual case of a simple polyp causing melaena in a boy thirteen years of age, who had his first attack at the age of three.

Isles of heterotopic gastric mucosa, as stated previously, may occur in Meckel's diverticulum or even line the entire diverticulum and predispose for ulcer formation. The ulcer is usually situated at the area where the gastric mucosa ends and the normal intestinal mucosa begins. This resembles very closely the marginal jejunal ulcer following gastroenterostomy. Ashner and Karlitz reviews the literature on this subject and reports thirty-three cases of proven or probable peptic ulcer of Meckel's diverticulum. Other cases reported (Etzchegorry, Flure, Patel, Lepart and Cobb) prove that the gastric mucosa could always be demonstrated at the site of the ulcer.

The etiology is not definitely established. Some believe (Greenwald, Steiner, Kaufman and Schaetz) it is the presence of gastric mucosa, with its secretion of hydro-

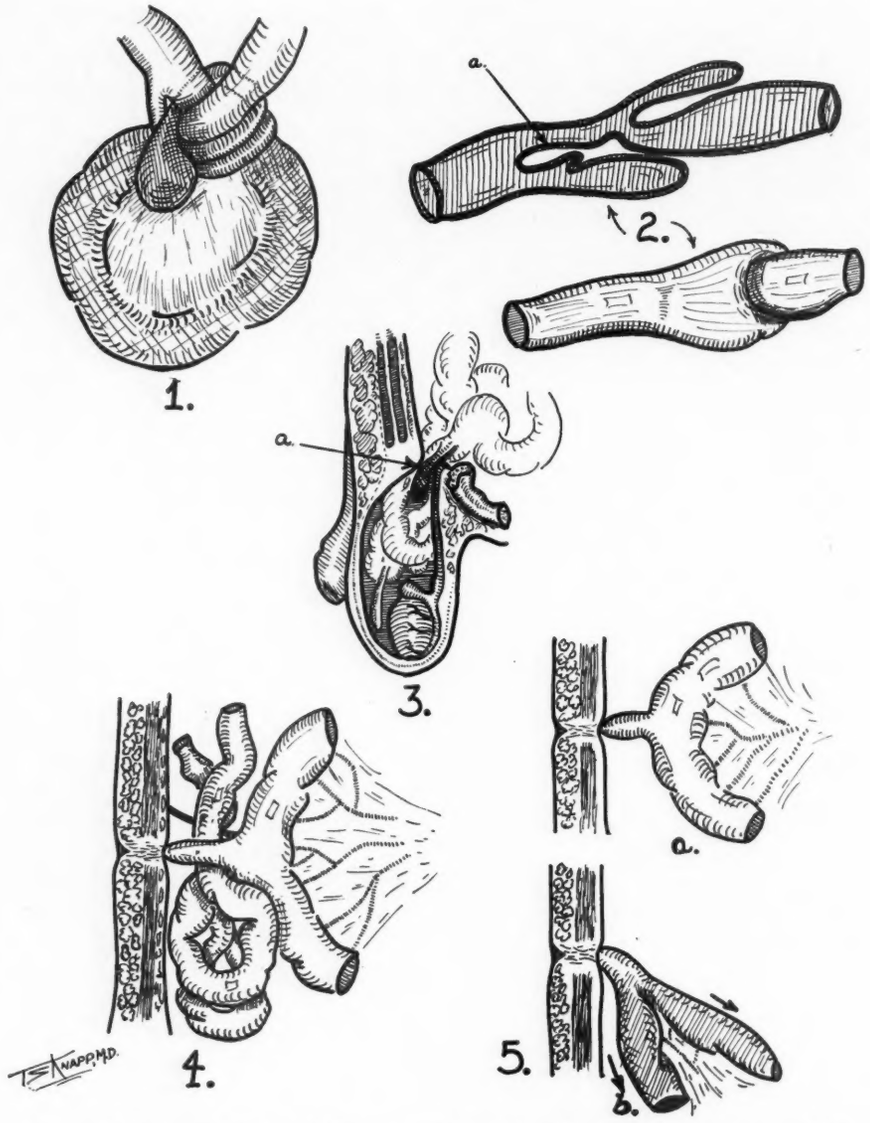

Fig. 4. Diagrams showing different types of intestinal obstruction caused by Meckel's diverticulum. 1, Strangulation of small bowel by double knotting of Meckel's diverticulum. 2, Intussusception of small bowel due to inversion of Meckel's diverticulum; *a*, Meckel's diverticulum. 3, Strangulation of Meckel's diverticulum in a congenital inguinal hernia; *a*, Meckel's diverticulum. 4, Strangulation of loops of small bowel due to a trap-like action of a Meckel's diverticulum adherent to the inner side of the umbilicus and persistent omphalo-mesenteric vessels. 5, Intermittent obstruction due to a Meckel's diverticulum adherent to the umbilicus; *a*, not obstructed; *b*, obstructed.

chloric acid and pepsin which predisposes to ulcer. Winkelbauer states that the causative factor is probably spasm of the diverticulum.

Intestinal hemorrhage of unexplained origin or abdominal pain of intense character might make one suspect, among other things, Meckel's diverticulum. Intestinal hemorrhage, due to peptic ulcer of Meckel's diverticulum, is a clinical entity in the disease of infancy. The complications of peptic ulcer of Meckel's diverticulum are the same as of any other peptic ulcer, bleeding and perforation. Schaetz, in his series, reports that the most frequent complication is that of hemorrhage which amounted to 81 per cent in his cases. The next frequent complication is perforation

in 56 per cent in his series of thirty cases.

The symptoms are either obscure or more or less those of a peptic ulcer. The hemorrhage originates usually from a peptic ulcer in the mucosa close to aberrant gastric mucosa at the neck of the diverticulum. The ulcer is not in the gastric mucosa itself.

OBSTRUCTION

The most common pathological changes resulting from Meckel's diverticulum are of the obstructive type. Mumford states that 6 per cent of all cases of obstruction are due to Meckel's diverticulum. Meckel's diverticulum, with partial obliteration and the formation of bands, is one of the most common causes of obstruction. Probably the first case of intestinal obstruction, due to Meckel's diverticulum and persistent omphalomesenteric vessels, was recorded by Van Doeveren and described by Sandifort in 1793.

The classification of the mechanics of intestinal obstruction as given by Ochsner:

I. With free unattached diverticulum
   (a) Knot tied around gut
   (b) Dragging and kinking of loop of intestine by distended or cystic diverticula
   (c) Twisting of bowel at origin of diverticulum
   (d) Chronic inflammation of diverticulum and intestine with narrowing of ileum
   (e) Acute diverticulitis

II. Diverticulum attached to the abdominal wall or abdominal viscus
   (a) Band constricting or interfering with blood supply
   (b) Volvulus of loop of intestine passing under diverticulum and becoming twisted
   (c) Volvulus of intestine attached to diverticulum with point of attachment as fixed point of rotation
   (e) Acute diverticulitis
   (f) Prolapse of intestine through an umbilical fistula.

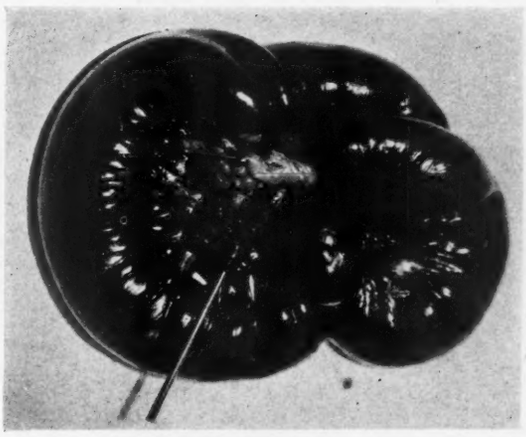

Fig. 5. Photograph showing gangrenous small bowel due to obstruction caused by double knotting of a Meckel's diverticulum; probe in Meckel's diverticulum.

Following peritonitis, Meckel's diverticulum may become adherent to the peritoneum and intestine and may prepare the way for possible obstruction. A pull or twist of the intestine by Meckel's diverticulum is a rather rare form of obstruction. The free Meckel's diverticulum may form a knot, or even a double knot, around the small intestine and mesentery.

Strangulation of the intestine by Meckel's diverticulum or its band formations, kink formations of the bowel by contracting bands, and adhesions are the more common types of disturbance. The diverticulum may strangulate itself by excessive rotation with resulting gangrene. Following intestinal ileus, eversion of part of the intestine into the diverticulum or invagination of the diverticulum into the intestine may occur. It is often found that invagination of Meckel's diverticulum is associated with invagination into the small bowel. Occasionally, however, invagination is found without involvement of the ileum. Tumors found in the invaginated Meckel's diverticulum, as lipoma, cylindroma, fibradenoma, accessory pancreatic tissue, make us believe that they probably have something to do with the invagination mechanism. The exciting factor in most cases of intussusception, however, is usually a nodule of pancreatic tissue situated near the fundus of the diverticulum. Lower reports that only fifty-two cases of intussus-

ception due to inverted Meckel's diverticulum have been mentioned in the literature. Hertzler, Gibson, Fauntleroy, Depish, Greenwood, Johnson, Hood, Vickers and Stone are among the authors reporting this type of intussusception.

Meckel's diverticulum occurs rarely in connection with hernia. Pabst reviewed 123 cases of this type and found sixty-six in inguinal, twenty-four in crural and eighteen in umbilical hernias. In fifty-four cases incarceration was present. Even rarer than the above mentioned types is the incarceration of a Meckel's diverticulum in connection with femoral hernia. Sweet reports such a case. In a review of literature from 1700 to 1929, he found listed only fourteen cases of incarcerated Meckel's diverticulum in femoral hernia. Brown tries to explain the etiology for the occurrence of Meckel's diverticulum in hernias by the fact that the mesentery at its origin is probably too short and, therefore, the small bowel located nearer to the different hernial openings.

The clinical symptoms of obstruction are the same as those of any other ordinary bowel obstruction, therefore, correct preoperative diagnosis is difficult, too.

PROGNOSIS AND MORTALITY

Prognosis and mortality vary with the severity of the condition and the time of operation from 7.6 per cent to 58 per cent. Early operation is followed by relatively low mortality (7.6 per cent), however, operation after perforation tremendously increases the mortality (58 per cent) (Greenwald).

Schaetz in his series reports a mortality of 38 per cent following perforated ulcer in Meckel's diverticula. Goodman reports a mortality of 9.3 per cent, Everhart 57 per cent, Hudson in his statistics shows a mortality of 22.2 per cent, others a mortality of 37.5 per cent.

ANALYSIS

Our analytical study is based on twenty-three patients with Meckel's diverticulum operated upon in the Charleston General Hospital by different members of our surgical staff in the years 1938 to May, 1945 inclusive. In this series, the preoperative diagnosis was correct only in one case and was taken into consideration as a second diagnosis in an additional case. The other findings were incidental to operation and exploration. In fourteen cases Meckel's diverticulum was without pathological change and apparently did not cause symptoms. In two cases the diverticulum showed only slight signs of inflammation. All cases in this series having accentuated symptoms were apparently due to obstruction, directly or indirectly caused by the anatomical variations of Meckel's diverticulum and its persistent omphalomesenteric vessels.

We conform, in our analysis, with the statements made by several other authors mentioned in the first part of this paper, that bowel obstruction is undoubtedly the most dominant disorder initiated by Meckel's diverticulum. Two Meckel's diverticula were incarcerated in inguinal hernias, one in a seven-months old infant and one in a fifty-three-year old man. An obstruction caused by double knotting of a free Meckel's diverticulum around a segment of bowel and its mesentery and one case in which a loop of small bowel became trapped between a Meckel's diverticulum adherent to the umbilicus and the persistent omphalomesenteric vessels, are probably the most interesting cases in our series.

Histological findings showed different types of heterotopia (gastric mucosa, duodenal mucosa, pancreatic tissue) but no ulcer formation. One patient died, probably because of extensive bowel damage and rather late surgical intervention.

The sex incidence, with a 2½ per cent greater frequency in male than in female, corresponds to the reports noted by the majority of the authors. The youngest patient was seven months and the oldest seventy-seven years old, with an average age of 31½ years. All our patients were of the caucasian race. We did not find any

comment in the literature on the relationship of race to Meckel's diverticulum.

CASE REPORTS

Case I. A—63130, R. S., a forty-one year old white male, was admitted to Charleston General Hospital on June 28, 1944, with the complaint of severe pain in the abdomen. He stated that he was in good health until the morning of the day of admission, at which time he was struck with a sudden pain in the epigastric region, which was so severe it caused him to "double up." The pain continued, became more severe at times and was of a cramping nature. There was pain in the epigastrium and in both lower quadrants, more pronounced on the right. He had one voluntary bowel movement the morning before the pain began. After the onset of pain he took some magnesium sulfate and three enemas, without results. He gave a history of frequent attacks of indigestion during the past three or four years, characterized by burning in the epigastrium one-half to one hour after meals. He stated that he is relieved by taking soda. His past history and family history were non-contributory.

Physical examination revealed the patient to be in acute abdominal distress. His temperature was 102.2°F., blood pressure 117/108, pulse 80 and respirations 20. There was marked tenderness and rebound tenderness in the epigastrium, to the right of the umbilicus and in both lower quadrants, however, more pronounced on the right. The abdomen was slightly distended. Rectal examination was negative.

The clinical laboratory findings were essentially negative except for a leukocytosis of 15,600 and neutrophils, segment 90 per cent. A scout plate of the abdomen was taken which did not show free air or any definite evidence of obstruction.

The impression, at the time of examination, was possible early obstruction; and that a subacute perforation of peptic ulcer should be excluded.

After routine preparation the patient was taken to the operating room and, under spinal anaesthesia, the abdominal cavity was entered through a right paraumbilical incision. Upon exploration of the abdominal cavity some free serous fluid was encountered. A Meckel's diverticulum about 10 cm. long was found to be adherent to the inner side of the umbilicus; the diverticulum originated from the antimesenteric portion of the ileum about two feet from the ileocecal junction. The proximal two-thirds of the ileum was distended and showed signs of beginning peritonitis. These findings were due to an obstruction, probably intermittent in character, caused by the pull of the intestine on the adherent Meckel's diverticulum. Relaxation of the intestinal pull released the obstruction. The diverticulum was resected in the routine manner and appendectomy done. The patient made an uneventful recovery and was discharged on July 5, 1944. This patient's ulcer symptoms for the last few years were probably caused by the diverticulum.

Case II. A—56289, K. B., a white man, twenty-three-years old was admitted to Charleston General Hospital on October 28, 1943, complaining of acute abdominal pain. He stated that he noticed several sharp pains about eighteen hours before admission. These pains were of crampy character and lasted from three or four minutes to as long as about an hour. He could not sleep well and was awakened a few hours later by a nightmare. This was followed in a few minutes by a rather sudden onset of acute generalized abdominal pain. Associated with the pain was nausea and vomiting. There was no hematemesis, no bowel movements and no history of previous attacks. His previous history and family history were non-contributory.

Physical examination revealed a twenty-three-year old white man, well nourished and developed, in acute abdominal distress. His blood pressure was 136/90 and temperature 98°F. There was very marked generalized abdominal tenderness and rebound tenderness, more pronounced in the left lower quadrant. Rigidity was present over most of the abdomen.

Clinical laboratory findings were: Urine: traces of albumen, 92 per cent hemoglobin, 4,800,000 erythrocytes, 21,000 leukocytes, 14 per cent lymphocytes, 3 per cent monocytes, neutrophils, stab 2 per cent and neutrophils segment 81 per cent.

A diagnosis of (1) intestinal obstruction and (2) diverticulitis was made. Exploration was under cyclopropane and ether anesthesia. A hard mass was encountered in the pelvis which, on further examination revealed an intussusception. Upon reducing the intussusception a

large gangrenous Meckel's diverticulum was found, which had become inverted into the lumen of the ileum and had been carried by peristaltic waves approximately 10 inches down into the small intestine. The diverticulum was resected in the routine manner and routine appendectomy was done.

Pathological report: (1) Intussusception of Meckel's diverticulum with a small area of mucosa and acute hemorrhagic necrosis; (2) appendix with remnants of old adhesions.

The patient made an uneventful recovery and was discharged on November 4, 1943.

Case III. A—61893, W. B., a fifty-four-year old white male was admitted to the Surgical Department of Charleston General Hospital on January 9, 1938, with the complaint of generalized acute abdominal pain. The day before admission this patient was taken with severe cramping and griping pain in the lower abdomen. Associated with pain was nausea and vomiting. He had not had any bowel movements since January 7th. Several enemas had been given but were not effectual. The patient stated he had had previous attacks of slight cramping lower abdominal pain, the last of which was about one year before. None were as severe as the present one. Family and previous histories were non-contributory.

Physical examination revealed: blood pressure 128/82, pulse 110, respirations 25 and temperature 99.6°F. The patient was somewhat undernourished, in acute distress and complaining of severe cramping pain over the entire abdomen. The abdomen was distended and rigid. There was marked tenderness and rebound tenderness over the entire abdomen. There was a tympanitic note on percussion.

Clinical laboratory findings: Urine; albumin +1, occasional red blood cells. Blood count: Leukocytes 18,600, lymphocytes 6 per cent, monocytes 2 per cent and neutrophils 92 per cent. The Kline exclusion was 3 and Kolmer Wassermann 4.

X-ray showed a moderate amount of gas throughout the small bowel and colon, with a local area of greater small bowel dilatation just below the umbilicus. This suggested small bowel obstruction, with a local area of strangulation.

Diagnosis: Small bowel obstruction, probably due to volvulus.

After preparation with intravenous fluids the patient was taken to the operating room (thirty-six hours after onset of symptoms). Under general anesthesia the abdomen was explored through a midright rectus incision. A large amount of bloody fluid was evacuated, after which it was found that a large part of the ileum was completely strangulated by the double knotting of a free Meckel's diverticulum, resulting in gangrene of about three feet of ileum. The entire gangrenous mass was resected and end-to-end anastomosis performed. The patient died on the seventeenth day after a stormy postoperative course.

Pathological Report: The specimen consisted of resected small intestine. The entire loop was about 100 cm. long. The intestine was very markedly distended, its wall blackish red in color and covered with a thin film of fibrin. Similar changes were present on the surface of the mesentery, the veins being markedly congested. Fifteen cm. distal from the place of resection a firm double knot was fixed around the afferent and efferent portions of the intestine, constricting it completely. In this area of constriction a cyst like portion of bowel was present, measuring 7 by 6 by 5 cm. On opening the afferent loop, branching of its lumen into two canals was found to be present. The larger part of the lumen allowed a thin probe to pass into the distended loops. Further examination showed that this was a Meckel's diverticulum which had become knotted around the ileum, its distended distal part forming the cyst like mass described above.

Diagnosis: Complete strangulation of a large part of ileum, due to double knotting of a free Meckel's diverticulum; hemorrhagic necrosis of the strangulated intestine with beginning local peritonitis.

Case IV. A—63298, M. M., a seven-months old white boy, was admitted to the Surgical Department of Charleston General Hospital on July 4, 1944. Twenty hours prior to admission the patient became acutely ill with fever and diarrhea, with passage of very frequent green, watery stools. This condition became increasingly worse. There was no vomiting. On the morning of admission the patient's mother noticed swelling and redness of the scrotum, the swelling becoming gradually more marked. This patient had always been weak, had been on a formula, carnation milk, with no breast feeding. He had had no childhood diseases. He had had an umbilical hernia since birth and developed generalized impetigo

about two weeks previous and was treated for this condition and showed some improvement.

Physical examination revealed a fairly well nourished, well developed seven-months male child, evidently acutely ill, very fretful when the abdomen was palpated. Temperature was 103°F. rectally, pulse 130. There were scattered dried old pustular skin lesions over the body. The lower abdomen was very tender and moderately distended. There was slight rigidity, more apparent in the right lower quadrant. A hard, tender elongated mass extended down from the area of the right inguinal canal into the scrotum. The entire scrotum was red and edematous, more so on the right side.

Clinical laboratory findings: Urine essentially negative. Blood count: Hemoglobin 59 per cent, erythrocytes 3,400,000, color index 0.86, total number of leukocytes 11,100, lymphocytes 51 per cent, monocytes 2 per cent and neutrophils 47 per cent.

The patient was in a rather poor general condition. A diagnosis of incarcerated right inguinal hernia was made and, after routine preparation, the patient was taken to the operating room.

A transverse incision, anatomical type, was made in the right inguinal region parallel to Poupart's ligament. The aponeurosis of the external oblique was split in the line of its fibers, the sac freed, delivered and opened. Almost the entire cecum, with the appendix and part of the terminal ileum were found in the sac and adjacent cavity. About eight inches from the ileocecal junction a diverticulum about ¼ to ½ inch long was found on the antimesenteric border of the ileum. Here were signs of hemorrhagic gangrene. This proved to be a true diverticulum containing all layers of the intestinal wall. In view of the patient's poor general condition resection could not be considered. The diverticulum was inverted transversely by two rows of interrupted Lambert sutures. The contents of the sac were replaced into the abdominal cavity, the sac ligated and hernia was repaired according to the Ferguson technic.

The postoperative course was rather uneventful except for the first postoperative day when his temperature went up to 105°F. rectally. He was discharged on June 14, 1944, in good general condition.

Case V. A—44641, R. B. a thirteen-year old white boy, was admitted to Charleston General Hospital on January 4, 1943, complaining of severe abdominal pain. This patient began to have generalized abdominal pain of cramping and burning character about two hours after his dinner. Shortly thereafter he started to vomit and continued to vomit numerous times. The pain continued to increase in severity, remaining generalized and cramping. There was no fecal vomiting and no chills. He had had no previous similar attacks. His past history was non-contributory. The patient had had the usual childhood diseases. His appetite previously was good and bowel movements normal.

Physical examination revealed a thirteen-year old boy in apparent acute distress, complaining of periodic abdominal pains. His temperature was 97°F. rectally, pulse 100 and respirations 24. The abdomen, especially the lower part, was distended and tender, more marked over the right lower quadrant and about the region of the umbilicus. There was rebound tenderness and muscle guarding over the same area. A tender, ill defined mass was found about 1 inch to the right and below the umbilicus. No other masses could be found. Peristalsis was active and not synchronous with pains. Rectal examination was negative.

Clinical laboratory findings: Urine essentially negative, hemoglobin 85 per cent, erythrocytes 4,600,000, leukocytes 30,000, lymphocytes 9 per cent, monocytes 4 per cent and neutrophils; stab 2 per cent and neutrophils segment 85 per cent.

A preoperative diagnosis of possible acute appendicitis was made, acute intestinal obstruction to be excluded.

After preparation with intravenous fluids, the patient was taken to the operating room and, under general anesthesia, exploration of the abdomen by way of a McBurney incision was performed. Two loops of the lower ileum were markedly discolored, almost black. A Meckel's diverticulum about 10 cm. long and 3 cm. wide, having about the same size and appearance as the ileum, was found about one foot from the ileocecal junction and extended to the undersurface of the umbilicus. About 2 inches from the umbilical attachment of the Meckel's diverticulum two string-like structures originated and extended to the ileum where they inserted into each side of the diverticulum 2 to 3 inches apart. In these compartments loops of incarcerated dark bowel

were caught. At the umbilical attachment of Meckel's diverticulum a peritoneal defect about 1 inch in diameter was found, exposing bare muscle. The string-like cords were resected, the diverticulum resected in the usual manner and the peritoneal defect repaired. The bowel was watched. Its normal color returned within twenty minutes. Routine appendectomy was done.

Postoperative Diagnosis: bowel obstruction due to Meckel's diverticulum adherent to the umbilicus by reason of persistent obliterated omphalomesenteric vessels.

This patient had a rather stormy postoperative course and developed signs of small bowel obstruction. On January 17, 1943, a secondary operation was undertaken. Ileocolostomy and cecostomy for relief of the bowel obstruction were performed. After a rather prolonged convalescence the patient left the hospital in good general condition on February 12, 1943.

COMMENT, SUMMARY AND CONCLUSIONS

A review of the embryological, anatomical and pathological factors of the Meckel's diverticulum was given with its relations to symptomatology, diagnosis and therapy. Twenty-two cases were analyzed and five cases of small bowel obstruction due to different types of Meckel's diverticulum are described in detail.

These cases are presented because of the interesting and rather unusual pathology they offer, also to stress again the point that to make a correct preoperative diagnosis of Meckel's diverticulum is difficult and, therefore, in any case of small bowel obstruction without apparent cause Meckel's diverticulum as an etiological factor should be considered.

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ULTRAVIOLET BLOOD IRRADIATION THERAPY*

FURTHER STUDIES IN ACUTE INFECTIONS

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IN the study of 445 consecutive and unselected cases of acute pyogenic infections and seventy-four cases of virus or virus-like infections we have found that our original observations[1,2] have been definitely confirmed and that not only sulfa-resistant infections have responded to this therapy but a high percentage of penicillin-resistant infections have also responded quite favorably.

In addition, we have observed that toxemias due to various virus or virus-like infections subside rapidly and in the same manner as those secondary to acute pyogenic infections,[3,4] an extremely important clinical advantage in dealing with a rapidly fulminating and overwhelming infection, the etiological agent of which is frequently discovered or suspected only after death has occurred.

TABULAR REPORT

The following tabular report including a wide variety of acute pyogenic infections is as follows:

RESULTS IN 445 CASES OF ACUTE PYOGENIC INFECTION GIVEN ULTRAVIOLET BLOOD IRRADIATION THERAPY AT THE HAHNEMANN HOSPITAL, PHILADELPHIA, OVER A PERIOD OF SIX AND ONE-HALF YEARS

	No. of Cases	Recovered	Died
Early			
Puerperal sepsis	3	3	
Incomplete septic abortion	12	12	
Acute furunculosis and carbunculosis	15	15	
Abscesses	2	2	
Acute Strep. hemolytic oropharyngitis	5	5	
Acute tracheobronchitis	12	12	
Acute wound infections	2	2	
Acute pansinusitis	1	1	
Acute pyelitis	1	1	
Acute otitis media	2	2	
Fever of unknown origin	1	1	
Moderately advanced			
Puerperal sepsis	14	14	
Incomplete septic abortion	57	57	
Acute furunculosis and carbunculosis	21	21	
Abscesses	13	13	
Acute Strep. hemolytic oropharyngitis	5	5	
Endometritis and parametritis	17	17	
Acute wound infections	6	6	
Salpingitis	15	15	
Peritonitis	18	16	2
Osteomyelitis	26	25	1
Fever of unknown origin	13	13	
Lobar and bronchopneumonia	11	11	
Atypical (virus) pneumonia	10	10	
Preoperative	13	13	
Postoperative	44	41	3
Non-healing wounds	6	6	
Thrombophlebitis	34	34	
Apparently moribund			
Puerperal sepsis	4	3	1
Incomplete septic abortion	2	1	1
Generalized peritonitis	4	2	2
Abscesses: Pelvic	6	5	1
Rectal	2	1	1
Scrotum	1	1	
Wound infections	3	2	1
Fever of unknown origin	2	1	1
Lobar and bronchopneumonia	2	1	1
Tb. meningitis	3	..	3
Mesenteric thrombosis, diabetes mellitus	1	..	1
Septicemias:			
Staph. aureus—albus with sulfa drugs	7	..	7
without sulfa drugs	9	9	
Str. hemolyticus	3	3	
Str. non-hemolyticus	2	1	1
Str. viridans—subacute bacterial endocarditis	13	..	13
Str. hemolyticus endocarditis	1	..	1
Str. non-hemolyticus endocarditis	1	..	1

Summary	Early	Moderately Advanced	Apparently Moribund
Number of cases	56	323	66
Number recovered	56	317	30
Percentage recovered	100%	98%	45%

* From the Blood Irradiation Clinic of the Hahnemann Medical College and Hospital of Philadelphia, Pa.

RESULTS IN 74 CASES OF VIRUS OR VIRUS-LIKE INFECTIONS

	No. of Cases	Recovered	Died
Early			
Primary atypical or "virus" pneumonia	2	2	
Poliomyelitis			
Bulbo spinal type	0	0	
Spinal type	36	36	
Moderately advanced			
Primary atypical or "virus" pneumonia	11	11	
Poliomyelitis (non-toxic)			
Bulbo spinal type	4	4	
Spinal type	11	11	
Mumps	1	1	
Apparently moribund			
Primary atypical or "virus" pneumonia	2	2	
Poliomyelitis			
Bulbo spinal type	7	6	1

The poliomyelitis patients were consecutively treated in an epidemic in which the mortality of the untreated acute bulbar cases exceeded 40 per cent, as opposed to that of 9 per cent in the cases above.

CASE REPORTS

Case 1. No. 79317½. S. H. A female, aged fifty-four, was admitted to Hahnemann Hospital, Philadelphia, Pennsylvania on July 5, 1942. She was not acutely ill before being admitted but was complaining of a severe pain in the right side and a full burning sensation in the rectum. Her temperature was 103°F., with no vomiting and no nausea. Laboratory data were as follows: hemoglobin 13.8, red blood count 4,360,000, white blood count 10,000, polymorphonuclears 80 per cent and lymphocytes 20 per cent. Respiration was 20, pulse 110 and blood pressure 110/66.

Abdominal examination revealed marked tenderness in the right and left lower quadrant, but no gallbladder tenderness and no costovertebral tenderness. Rectal examination revealed tenderness and a possible mass near the rectal-sigmoid junction.

Given sulfathiazole, 15 grains every four hours, her condition improved, but on her eleventh hospital day her temperature began to rise again with chills, the rises being of a characteristic spiking nature. Blood cultures, however, were negative as was the Widal.

The red blood count deteriorated to 1,970,000, white blood count to 7,300 and hemoglobin to 6.8. Frequent blood transfusions were necessary. *X*-ray showed either an acute diverticulitis or a walled off pocket in connection with the sigmoidal lumen.

On August 3, 1942, her temperature rose to 104.2°F. The patient was sigmoidoscoped and a large amount of pus drained from an abscess at the rectosigmoid junction. In spite of this the patient's temperature did not subside, and when seen on August 6th, was apparently moribund with Cheyne-Stokes respiration, showing a rapidly falling blood count, a temperature of 104°F, increasing toxemia and a rapid spread of the infection. The patient was semi-comatose, anuric, edematous and in early shock. Her extremely toxic condition was believed to be due to two factors: (1) overwhelming toxemia of bacterial infection, (2) the toxic effects of sulfathiazole, which failed to control infection.

Ultraviolet blood irradiation therapy with 200 cc. of citrated blood was given, and sulfa drugs were stopped; the patient's condition inproved with supportive fluids and blood transfusions during the next forty-eight hours. Her temperature dropped to a level of 101°F to 102°F. The toxic condition subsided slightly and the patient was more rational, taking some food and voiding normally for the first time in more than a week.

On August 10, 1942 a second ultraviolet blood irradiation with 275 cc. of citrated blood was given after which the patient's temperature receded to nearly normal with a marked improvement in her general condition. The white count rose to 11,700 from the pre-irradiation value of 6,000. The patient now had normal bowel movements, ate well and regained strength. Rectal examination produced no more pus, but a mass in the sigmoid could still be felt.

On August 19th, the patient's temperature, pulse and respiration rose to 102°F, 130, 38 respectively and her condition deteriorated somewhat. The white blood count was 9,600.

Another ultraviolet blood irradiation of 275 cc. of citrated blood was given to which the patient responded in forty-eight hours with a normal temperature, a subsidence of toxic symptoms, lowered pulse and respiratory rate to 100 and 20 respectively.

The diagnosis was para-rectal abscess, and perforation of sigmoid diverticulum with abscess formation, rapid spread of infection.

The patient made an uneventful recovery and was discharged two weeks later on September 2, 1942, in apparently good condition.

Case II. No. 83812. V. P. A female patient, aged fifty-nine, was admitted to the McKinley Hospital, Trenton, New Jersey, on July 18, 1944, suffering from an acute cholecystitis with a temperature of 102°F.

A cholecystectomy was planned after her acute symptoms had subsided. She was, therefore, immediately put on sulfathiazole 15 grains every four hours and 20,000 units of penicillin every four hours day and night. The sulfa drug level was kept between 2 mg. per cent to 6 mg. per cent for two weeks. On the second day an additional 30,000 units of penicillin were given by vein. This therapy was supported by blood transfusions of 250 cc. on the fifth, sixth, seventh and eighth hospital days.

In spite of this intensive therapy the patient's condition became increasingly critical and her temperature curve was definitely of a septic nature. Blood cultures were negative, urine was negative, blood chemistry normal, red count 4,350,000, white count 10,050 and hemoglobin 93 per cent. All agglutination tests were negative and Wassermann was negative.

On the twelfth day another 100,000 units of penicillin were given intravenously with a 500 cc. blood transfusion, as a rectal hemorrhage had occurred the day before.

On the fourteenth day the patient was considered hopelessly moribund by her attending physicians. She was semi-comatose, irrational and anuric. Her body was covered with a macular rash and there was noted an extensive edema of the eyes, face and ankles. At 6 P.M. of that day ultraviolet blood irradiation therapy, (250 cc. of citrated blood), was given and sulfa drugs stopped. The patient's temperature was 106°F. at this time. At 10 P.M. her temperature rose to 108°F. with chills. One-half hour later, however, her temperature began to drop, as profuse sweating appeared. Urine was passed for the first time in forty-eight hours. The following morning the patient became rational again. About eighteen hours after ultraviolet blood irradiation therapy her temperature dropped to 97°F., rising that evening to 101°F. In the next four days the patient made a most remarkable recovery; her temperature stayed normal, the rash disappeared, her appetite improved and all tenderness in the gallbladder region subsided. Normal amounts of urine were voided consistently. Penicillin, 20,000 units every four hours were continued after ultraviolet blood irradiation therapy. In spite of this the patient developed signs of a beginning hypostatic pneumonia of the right lower lobe with temperature up to 102°F., on the sixth and seventh days after ultraviolet blood irradiation therapy. Another application of ultraviolet blood irradiation therapy with 250 cc. citrated blood was given at this time, eight days after the first; the symptoms of pneumonia subsided promptly after forty-eight hours.

The diagnosis was acute fulminating cholecystitis with overwhelming toxemia.

The patient made an uneventful recovery and was discharged on the twenty-ninth day without an operation being considered necessary and to date has shown no signs of cholecystitis.

Case III. No. 79187. T. N. A male, fifty years of age, was admitted to the McKinley Hospital, Trenton, New Jersey, on May 5, 1943, for treatment of rheumatoid arthritis. He progressed favorably until May 31st, at which time gold thiocyanate was started, but withdrawn as the patient became acutely ill with fever, chills, and temperature of 104°F. Two days previous to this flare-up the patient had a tooth with infected roots extracted, and blood culture taken at this time was positive for Streptococcus viridans. He became progressively worse during the following four days despite intensive sulfathiazole therapy.

It was believed by the patient's physician that the prognosis was grave, as the patient had become semi-comatose and irrational. Ultraviolet blood irradiation was recommended as a last resort and was given on June 4, 1943, as soon as sulfathiazole was withdrawn. This was followed by a most dramatic result. The patient's temperature began to fall and in twenty-four hours he was apparently out of danger and at the end of forty-eight hours his temperature was normal and blood cultures were negative. The patient convalesced uneventfully and left the hospital in good condition on June 31, 1943.

The diagnosis was streptococcus viridans septicemia.

He has received thirteen blood irradiations since that time, the last one given on April 13, 1946. His rheumatoid arthritis is well con-

trolled and to date there has been no sign of Streptococcus viridans present in the blood stream for two years and ten months after his attack of Streptococcus viridans septicemia.

Case IV. No. 851702. R. G., a fourteen-year old male, was admitted to the hospital October 21, 1943, with extensive enlargement of the right parotid area, slight early enlargement of the left parotid and temperature of 102°F. The condition had lasted for twenty-four hours and was diagnosed as mumps.

Ultraviolet blood irradiation therapy using 200 cc. of the patient's blood plus 40 cc. sodium citrate was given October 21st. Slight or mild toxemia was present. On the twenty-second he showed marked improvement twenty-four hours after irradiation. The swelling on the right side was less, and the left side subsided completely. The temperature was 99.0°F. The patient felt better, had a good appetite and ate a full breakfast. On the following day his temperature was 98.6°F, and the swelling on right side was less. The patient was discharged October 30, 1943; all swelling had completely disappeared.

Case V. No. 21168. R. C. a seventeen year old male, a post-scarlet fever patient was admitted to U.S. Public Health Service Hospital, Sheepshead Bay, New York, on April 9, 1945. He complained of a productive cough for the past two weeks and of pain in the left lower chest on deep breathing during the previous week.

His temperature on admission was 105°F. and his physical examination revealed râles, dullness and diminished breath sounds over the left lower lung.

The following day his temperature dropped to normal and he did not seem ill; *x*-ray examination showed only a small area of patchy infiltration of the left lower lung field at the cardiophrenic angle. He convalesced uneventfully until on the fourteenth hospital day his temperature began to rise and penicillin was begun. In forty-eight hours his temperature had risen to 105°F. and he was definitely toxic. In another forty-eight hours the patient had become comatose, had renal failure, a blood pressure of 150/90, blood urea nitrogen of 82, blood sugar of 266, carbon dioxide combining power of 34; a diagnosis of acute nephritis was made. On the following day he developed muscular twitching. He came out of the coma but only temporarily. He began to show evidence of increasing pulmonic complications despite the vigorous use of penicillin, so much so that *x*-ray examination on May 4th, showed an extensive pneumonia involving the whole lower two-thirds of both lung fields plus a narrow effusion of the right chest, causing 20 per cent compression of the right lung and probable pleuritic reaction of the lower one-third of the left chest. The pneumonic process became increasingly severe for the next four days and since it was apparent from the sputum findings that a penicillin-resistant hemolytic streptococcus was the causative organism, it was believed that the youth was apparently moribund and the prognosis extremely grave. A three-day trial of sulfadiazine had also been ineffective. Due chiefly to its availability, ultraviolet blood irradiation therapy was instituted on May 8th, at which time the patient's temperature was 104.2°F., pulse 120, respiration 36; the patient was semi-comatose and irrational.

The diagnosis was Streptococcus pneumonia, glomerular nephritis and secondary hypertension.

On the first post-irradiation day the patient seemed slightly improved. In forty-eight hours he was less toxic and more rational, though still quite dyspneic. His temperature remained about 101°F. By the fourth post-irradiation day he was definitely improved though still moderately dyspneic and complaining slightly of pleuritic pain. His color had improved.

On May 14th, *x*-ray examination showed a moderate clearing of the left pleural sac and a diminished pocket in the right. The diagnosis was "resolving bilateral pneumonia." His general condition continued to improve; his temperature had fallen to a level between 98.4°F. and 100.4°F.

Further *x*-ray examination on May 17th, showed the continued resolution of the bilateral pneumonia with a narrow layer of fluid between the right lung and chest wall and right diaphragm. After May 16th, the patient's temperature failed to rise beyond 99°F., his blood pressure, now normal, also remained normal.

A certain amount of pleuritic reaction remained, and a small amount of fluid could be observed May 24th.

Penicillin, which had been continued empirically and possibly to some extent detrimentally, was finally discontinued May 26 1945.

All dyspnea had disappeared but some tachycardia remained; although on May 29th, there was still some fluid in both lungs, the patient's general condition remained excellent and his lungs finally cleared to the extent that he was discharged in good condition June 27, 1945.

Case VI. No. 64360. D. G. an eleven-year old boy was admitted to Hahnemann Hospital, Philadelphia, August 8, 1942, with severe cough, chest pain, fever, toxemia and cyanosis. There was a history of cough and fever for six days previous to admission. Physical examination of chest revealed slight impairment of breath sounds over the right scapular area and fine crepitant râles over both apices. Laboratory examination showed a blood count of 4,040,000 red blood cells, 8,400 white blood cells, negative urinalysis and negative agglutination for Bacillus typhoideus, Bacillus paratyphoideus, A and B, Bacillus abortus and proteus OX 19. Sputum showed Micrococcus catarrhalis in predominance, no pneumococci on culture and the blood smear for Plasmodium malariae was negative. Roentgenological examination on August 31st, showed an acute inflammatory process extending into the lung fields from both hilar areas; a second chest *x*-ray taken September 2nd, showed further invasion by the acute inflammatory process in keeping with a definite deterioration of the child's general clinical condition after two to three days of hospitalization; at this time the red cell count had fallen to 3,460,000, the white count to 5,400.

The diagnosis was primary atypical or "virus" pneumonia with severe toxemia.

Since a virus type of progressing pneumonitis was considered present, and no other therapy was believed effective, ultraviolet blood irradiation therapy was administered.

In twenty-four hours the patient's clinical condition was slightly improved, though *x*-ray examination revealed little change, if anything a slight progressing of the inflammatory process. The boy's temperature which had been 103.4°F. on the day of irradiation dropped to 100°F.

At the end of forty-eight hours the child's condition had greatly improved, his temperature fell to 98.6°F. for the first time and his severe toxic symptoms had completely subsided; a normal pink color had appeared and his cough seemed less severe. His red cell count rose to 4,350,000, and his white count to 6,400. From then on he convalesced uneventfully and a roentgenological examination taken September 8th, showed a complete clearing of the lung fields; he left the hospital on that date, six days after a single blood irradiation.

Case VII. No. 858545. L. T. a twelve-year old boy, when seen had moderate toxemia, some encephalitis manifestations present, temperature 103°F., marked back, bilateral hamstring and gastrocnemius spasm, weakness of both legs, left arm, inability to void and beginning of respiratory difficulty.

Blood Count		Spinal Fluid	
White blood cells.....	13,000	Cells.....	180
Polymorphonuclears.....	80%	Pandy....	one plus
Hemoglobin.....	80%		

The diagnosis was spinal poliomyelitis with progression of muscular weakness.

Ultraviolet blood irradiation therapy was instituted October 31, 1943, using 165 cc. of the patient's blood plus 33 cc. sodium citrate. The following day the patient was about the same, although the tendency to develop encephalitic symptoms has disappeared. His temperature returned to normal November 2nd, the toxic symptoms subsided and no extension of paralysis appeared. By November 3rd, his general condition had greatly improved, with no apparent change in paralytic symptoms. On November 4th ultraviolet blood irradiation therapy, 150 cc. patient's blood plus 33 cc. sodium citrate was again used. His temperature rose to 99.2°F. All acute symptoms then subsided.

Case VIII. No. 859253. T. H., a twenty-three-year old female, had grave, progressive respiratory paralysis, (complete), toxic with a temperature of 102°F. Both arms and both legs were paralyzed, she was unable to swallow, and was cyanotic even in the respirator. The patient was six months pregnant.

The diagnosis was acute bulbar and spinal poliomyelitis.

Ultraviolet blood irradiation therapy, 180 cc. of the patient's blood plus 36 cc. of sodium citrate was used November 9, 1943. The patient could not be moved from the respirator for any length of time, which necessitated that

the irradiation be given while the patient was in the respirator.

The following day the toxic symptoms were gone and her temperature was 98.6°F. The patient was able to swallow and her color was good. However, complete respiratory failure, and paralysis in both arms and legs were still present.

Thirteen days later color was again poor and definite cyanosis was present. Ultraviolet blood irradiation therapy was repeated, using 180 cc. of the patient's blood plus 36 cc. of sodium citrate. Difficulty in swallowing reappeared. Her color was improved; she rested comfortably apparently, swallowing was made easier, but no change was evident in the paralytic symptoms. By November 30th, the patient was eating well and in general was greatly improved.

While in the respirator a normal male infant was delivered at term, the first such successful delivery of a bulbar poliomyelitis mother in California.

CLINICAL OBSERVATIONS

Treatment of Sulfa Resistant Infections. The definite limitation of sulfa drugs in the treatment of infection has long been apparent to us since for over seven years we have been treating sulfa drug failures, known more euphemistically as sulfa-resistant infections. Continued work in the treatment of sulfa drug failures has greatly strengthened our original belief that sulfa sensitive infections are easily and favorably influenced by ultraviolet blood irradiation therapy and that a large variety of infections not controlled by sulfa drugs can be rapidly and efficiently controlled by ultraviolet blood irradiation therapy.

In sixty cases of sulfa drug failures ultraviolet blood irradiation therapy was found successful in controlling the acute infection in most instances. As might be expected, acute infections of apparently a virus or virus-like nature were found, when treated by sulfa drugs, to be either uninfluenced or, as occurred in a majority of cases, the infection was believed to have spread more rapidly than ever following the use of sulfa drugs. This was in sharp contrast to the rapid subsidence of such infections when treated with ultraviolet blood irradiation therapy alone or after sulfa drug failure.

It is our carefully considered opinion that, in the treatment of most acute pyogenic infections and some virus-like infections, ultraviolet blood irradiation therapy is a far safer and much more efficient method of treatment than is chemo-therapy with sulfa drugs.

Treatment of Penicillin-Resistant Infections. In penicillin-resistant cases, we have found that ultraviolet blood irradiation therapy is a valuable therapeutic agent when used to control penicillin-resistant infections, whether of acute pyogenic type or the virus or the virus-like type.

The chief penicillin-resistant infections in which we have used ultraviolet blood irradiation therapy to control the infection have been those due to Streptococcus hemolyticus and colon bacillus and those of a virus or virus-like nature.

As a result of our experience in the use of ultraviolet blood irradiation therapy in penicillin resistant cases, we have been able to make the following pertinent observations:

(1) As might be expected, patients who have received penicillin without effect do not come to us as a rule with the profound toxemia that is so uniformly present in sulfa drug failures. Since no extra toxic burden has been added to the patient by the drug used, more can be expected from the use of ultraviolet blood irradiation therapy in pure penicillin resistant failures than in sulfa drug failures, provided that patient is not first seen in a hopelessly moribund state.

(2) There is no contraindication to the combination or synchronized use of penicillin with ultraviolet blood irradiation therapy, as is the case with sulfa drugs. Penicillin can be given safely before, during or immediately after ultraviolet blood irradiation therapy, since there is no photosensitization factor to be considered.

(3) Inasmuch as ultraviolet blood irradiation therapy controls certain virus or virus-like infections rapidly and efficiently and penicillin does not, ultraviolet blood irradiation therapy must be considered the procedure of choice in these infections.

(4) The rapid and favorable response of Staphylococcus septicemia to either penicillin or ultraviolet blood irradiation therapy used independently of the other, plus the lack of contraindication to a combined use of both agents, suggests that the ideal treatment for all severe staphylococcic infections is the combined treatment of the infection,using both ultraviolet blood irradiation therapy and penicillin simultaneously.

(5) Ultraviolet blood irradiation therapy by its very non-specificity has many advantages over penicillin in that it provides safe, rapid and efficient control of acute fulminating infections, regardless of whether or not such infections are due to penicillin-sensitive bacteria.

Blood Irradiation Alone in Acute Infections. (1) Ultraviolet blood irradiation therapy used alone is, in our opinion, the ideal method of controlling acute bacterial infections either of an acute pyogenic nature or of a virus-like character.

(2) It is a safe, reliable and non-specific method of controlling acute infections.

(3) It insures adequate ultraviolet intake to those whose protective immunological reactions are in the process of deterioration. This deterioration, even when progressing rapidly, has been observed to be reversed in a definite manner following ultraviolet blood irradiation therapy, resulting in consistent clinical improvement.

(4) A marked decrease in hospitalization time for such infections has been observed by us as well as other workers in the field[5,6,7,8] following the use of this method.

(5) When blood irradiation was used in the acute infections reported here, the use of sulfa drugs or penicillin was believed to be entirely unnecessary, with the possible simultaneous use of penicillin in Staphylococcus septicemia and the absolute use of penicillin in bacterial endocarditis.

(6) The detoxification effect originally reported to occur twenty-four to forty-eight hours after the use of ultraviolet blood irradiation therapy in acute pyogenic infections was also noted after its use in virus or virus-like infections. This finding has also been recorded by Barger[15] and Newman[16] in acute bulbar poliomyelitis patients following ultraviolet blood irradiation therapy.

Preoperative Protective or Rebbeck Effect. Rebbeck originally described the occurrence of a powerful preoperative effect following the use of ultraviolet blood irradiation therapy before operation, i.e., uterine dilatation and curettage in cases of incomplete septic abortion.[8] We have repeated this work in twenty-six consecutive cases and can definitely confirm this original report of Rebbeck's. We have likewise found that one may remove with impunity infected teeth and tonsils in the face of an acute rheumatic process with or without associated myocardial damage.

The tremendous potentialities for preoperative protection should be obvious to both surgeon and internist who are constantly faced with the well known dilemna of the poor surgical risk patient with dangerous foci of infection producing or aggravating the chief disease process.

It seems to us that Rebbeck's contribution to safer surgery is most important; furthermore, his preoperative protective effect has been confirmed by others besides ourselves, notably Hancock,[5] Moser,[6] Olney[7] and Barrett.[8]

SUMMARY

1. The study of the clinical effects of ultraviolet blood irradiation in 445 consecutive and unselected cases of acute pyogenic infections has been made. Confirmation of our original preliminary findings was observed. These findings showed that ultraviolet blood irradiation therapy was a rapid, efficient and non-specific control of all types of acute pyogenic infections (except bacterial endocarditis), the use of which was characterized by a quick subsidence of toxic symptoms, a disappearance

of bacterial proliferation and invasion and an uneventful convalescence.

2. In seventy-four consecutive and unselected cases of virus or virus-like infections we have observed results comparable to the favorable effects observed in its use in acute pyogenic infections.

3. It was found that sulfa sensitive infections are easily and favorably influenced by ultraviolet blood irradiation therapy and that a large variety of infections not controlled by sulfa drugs can be rapidly and efficiently controlled by ultraviolet blood irradiation therapy.

4. Many penicillin-resistant infections respond favorably to ultraviolet blood irradiation therapy, both the acute pyogenic types and the virus or virus-like infections.

5. We were able to confirm the preoperative protective effect of ultraviolet blood irradiation therapy described by Rebbeck and fittingly called the Rebbeck Effect.

6. There is no contraindication to the joint use of penicillin and ultraviolet blood irradiation therapy, but sulfa drugs cannot be safely used in the first four or five days following ultraviolet blood irradiation therapy.

CONCLUSIONS

1. Ultraviolet blood irradiation therapy is in our opinion the safest and most efficient method of controlling most acute pyogenic infections with one notable exception, namely, subacute bacterial endocarditis.

2. Ultraviolet blood irradiation therapy in our opinion is the procedure of choice in the treatment of sulfa-resistant and penicillin-resistant infections of the acute pyogenic infection type.

3. Ultraviolet blood irradiation therapy is the procedure of choice in the treatment of acute infections of a virus or virus-like nature, and should be tried out universally for such infectious disease processes.

4. The preoperative use of ultraviolet blood irradiation therapy allows the safe removal of foci of infection in such serious disease as incomplete septic abortion with or without an associated septicemia, acute rheumatic fever with or without extensive myocardial damage, acute exacerbations of chronic rheumatoid arthritis and advanced bronchial asthma.

5. It is our belief that staphylococcemias can be most effectively controlled by joint use of penicillin and ultraviolet blood irradiation therapy.

6. These results are in close agreement with those obtained by other workers in this field.[9–15]

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MYOPHAGISM CONGENITA*

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THE atrophy or wasting away of muscular tissue which is found in arthrogryposis multiplex congenita is caused by a primary muscular degeneration with secondary joint changes manifested by severe contractures involving the extremities. Myophagism is the descriptive term which in one word seems to best fit the type of muscular atrophy found in this condition. The following descriptive terms have been used in the past by these authors: Stern[3]—arthrogryposis multiplex congenita; Middleton[8]—myodystrophia foetalis deformans; Sheldon[7]—amyoplasia congenita; Rocher[6]—multiple congenital articular rigidity.

A. G. Otto[1] in 1841 was the first to describe this anomaly. In 1905, Rosenkranz[2] attempted to explain the etiology. In 1923, Stern gave it the name arthrogryposis and discussed the etiology. In 1925, Lewin[4] gave the derivation of the term coined by Stern. In 1932, Sheldon described the condition from the view point of a degenerative muscular atrophy and called it amyoplasia congenita. In 1934, Middleton discussed the comparative pathology, called it myodystrophia foetalis deformans and drew an analogy between this condition and the muscular dystrophies of post-natal life. In 1943, Badgley[9] attempted to describe the etiology as due to a failure of normal rotation of the limb bud.

The fact that there have been several theories as to the cause of this condition proves that this has not been definitely settled, but most of the extensive studies seem to indicate that the cause of the deformities is a muscular degeneration with secondary joint changes. The joints are formed normally and the epiphyses are normal. The contractures of the muscles produce malformation of the major joints. Stern stated that the etiology may be do to pressure on the fetus resulting in contractures. A history that the mother did not experience "quickening" until the sixth month of pregnancy which soon faded away entirely is usually obtained in the majority of instances. Stiffness of the joints results from lack of fetal motion; this is in keeping with embryological evidence from limb buds transplanted into regenerating paralyzed muscle. Middleton in his investigations found that the muscles of lambs were very wasted and composed largely of fat and that among the fat could be seen occasional oval cells with central nuclei. These cells were clearly muscular in type and could be interpreted as undeveloped muscle cells in the myoblastic stage of differentiation or degenerating myocytes. Hutt[10] described a hereditary lethal muscle contracture occurring in calves and mentions that this condition may be found in other species of the artiodactyla. Roberts[5] described a similar congenital deformity occurring in lambs. The deformity was transmitted in sheep as a simple autosomal recessive factor described as "stiff jointed lambs." The deformity consisted of the presence of contractures of the muscles of the limbs with limitation of motion in the joints which were themselves normal on dissection. The muscles were found degenerated and the muscle fibers replaced with fat in the full term lamb. Sections of muscles removed from the premature animals showed degeneration of the muscle fibers with secondary fat replacement. There were no abnormalities found in the central nervous system or peripheral nerves, and

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Fig. 1. Case I. Dislocated hips, the result of contracture and shortened gluteal muscles.

Fig. 2. Excellent reduction of dislocated hips obtained by abduction.

electrical tests of the affected muscles revealed no response or a weak normal result. The reaction of degeneration is never present. In the human the muscles of the diaphragm are apparently normal but in animals this organ consists of a fibrous sheet with little or no muscular tissue which accounts for the respiratory failure and death at birth. The muscles although abnormal are present. The muscles of the limb bud are a later development than those of the trunk and arise from a different source which accounts for the fact that the limb muscles alone are affected. The muscular degeneration has its onset about the third to the fourth month of fetal life and progresses rapidly reaching its maximum and ceases at birth.

This is a fascinating subject and the ingenuity of the orthopedic surgeon will be taxed to the utmost as to correction of the deformities and makes what at first appears a hopeless situation into one that modern orthopedic surgery can with persistent effort overcome. The mentality of the patients affected is usually within the average normal and since they are handicapped because of the marked deformities consisting of club hands, club feet and contractures of the major joints it is conceivable that these unfortunate individuals may be treated as domicile and institutional patients. It has been stated that it is characteristic of the dislocation of the hip joints that the reduction is difficult. In one of our patients (Figs. 1 and 2) an excellent reduction was obtained by simple abduction over a long period of time. The coxa vara deformity may be produced by the shortened gluteal muscles pulling up the trochanter. (Fig. 3.)

Plastic and reconstructive surgery can do much to help make more than a bedridden patient of these handicapped children. The use of fusions, osteotomies, capsulotomies, manipulations and stretchings are some of the procedures which have been used and should be attempted; for everything is to be gained and nothing lost in the treatment of these patients. Each procedure requires prolonged hospital care and these children are best treated in a crippled children's hospital where expert physiotherapy, occupational therapy and attendance at school can be attained. Ambulation of these patients is a problem

Fig. 3. Case II. Coxa vara deformity.

Fig. 4. Case 1. Result of supracondylar osteotomy right femur, enabling patient to stand and walk with crutches.

which must eventually be considered. One of our patients afflicted with a severe involvement is now walking with crutches. Following is an account of three patients who were treated with reconstructive surgery:

Case 1. This patient presented a severe contracture of both upper and lower extremities. Both hips were dislocated (Figs. 1 and 2) and during the course of her early treatment the hips were maintained in abduction and an excellent result was obtained. A supracondylar osteotomy of the right femur was done recently and it is contemplated that a similar procedure be done on the left femur. The patient can now walk with the support of crutches. (Fig. 4.) This is considered an achievement considering the fact that she was a bedridden and wheelchair patient for a long time.

Case 11. This nine-year old boy was treated for correction of his club feet by subastragalar fusions and tendon lengthenings of the heel cords. A resection and capsulotomy of the right elbow joint to correct severe contracture was performed with good results. Figure 3 demonstrates the coxa vara deformity of the hips. It is contemplated that reconstruction of the left elbow and both hands be done, plus supracondylar osteotomies of both femora in order to correct the flexion deformity of the knee joints. (Fig. 5.)

Case 111. This boy was the sixth of seven children. There is a history of a difficult labor. At birth the upper extremities were internally rotated and the elbows extended with contractures of both axillae. The lower extremities

Fig. 5. Case II. Severe muscular degeneration with contractures of extremities.

Fig. 6. Case III. Range of motion of upper extremities.

Fig. 7. Case III. Contracture of both axillae; muscular atrophy about shoulders; correction of feet.

were normal except for the right foot which presented a mild varus deformity. This patient received intensive physiotherapy and manipulations and at the present time he has useful upper extremities as demonstrated in Figures 6 and 7. The foot was treated by manipulation and corrective shoes.

Myophagism congenita has been selected to describe this peculiar symmetrical atrophy or wasting of muscular tissue. The term is derived from the Greek meaning, "to consume muscle tissue." The reaction is of a phagocytic nature occurring prior to birth and it is selective in that the extremities alone are involved.

SUMMARY

A primary muscular degeneration with secondary joint contractures is discussed. Myophagism congenita which is derived from the Greek meaning, "to consume muscle," is the term selected to describe the condition. The comparative pathology and the orthopedic treatment is stressed.

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USE OF TANTALUM FOR FACIAL AND CRANIAL DEFECTS

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THE search for a metal or metallic alloy suitable for tissue replacement has been going on since the sixteenth century. Gold, silver, steel, aluminum, magnesium, brass and Vitallium have all been used. However, all these metals oxidize in body fluids, provoke foreign body response and show high electrolytic reaction. Most serviceable metal in this group is Vitallium which, prior to the introduction of tantalum, was most successfully used.

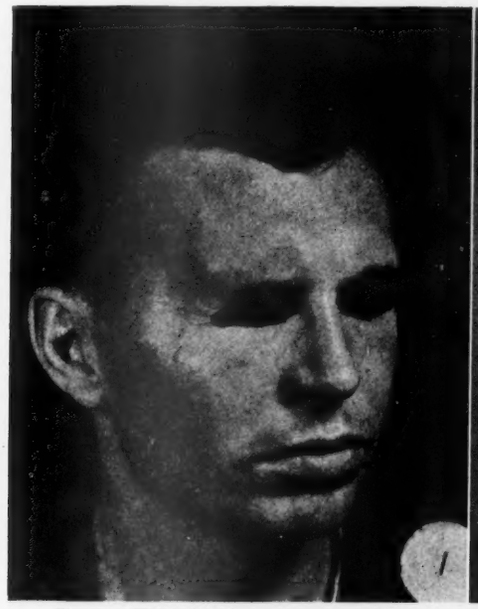

FIG. 1. Facial defect; preoperative.

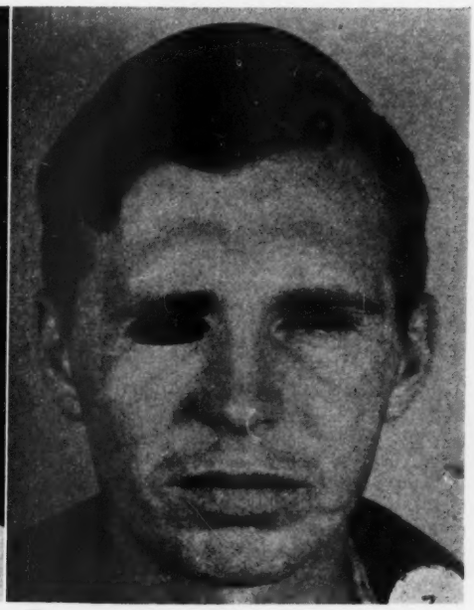

FIG. 2. Same case as Figure 1, postoperative.

Advantages of Tantalum. Tantalum seems the best metal now available for the repair of cranial and facial defects. It is an element with many unique properties. Blue-gray in color, it has the characteristics of mild steel. In its annealed state, it is ductile and workable. Biologically, it seems inert. Experimental evidence indicates that it becomes encapsulated without continuous progressive "piling up" of tissues. This is an important quality. It is more useful than Vitallium because the latter cannot be cut, shaped or trimmed in the operating room. It is difficult to carve a piece of bone or cartilage to fit a defect on one side of the face and expect it to match the contour on the uninjured side. With tantalum this can be done.

FIG. 3. Same case as Figure 2; tantalum plate in place.

FIG. 4. Facial defect; preoperative.

FIG. 5. Same case as Figure 4; postoperative.

FIG. 6. Facial defect; preoperative.

FIG. 7. Same case as Figure 6; postoperative.

FIG. 8. Same case as Figure 6; roentgenogram showing tantalum plate.

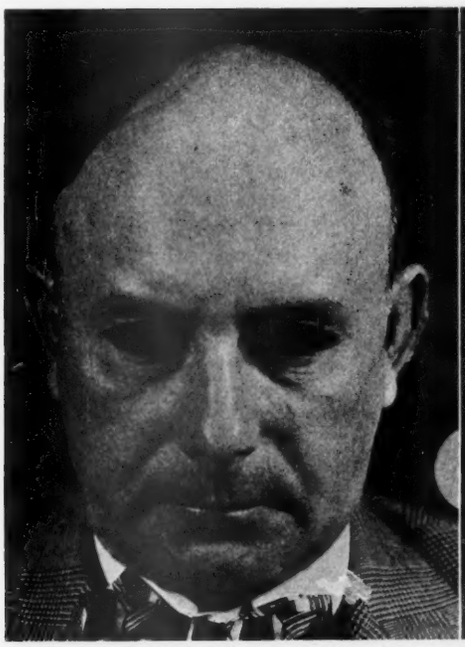

Fig. 9. Cranial defect; preoperative.

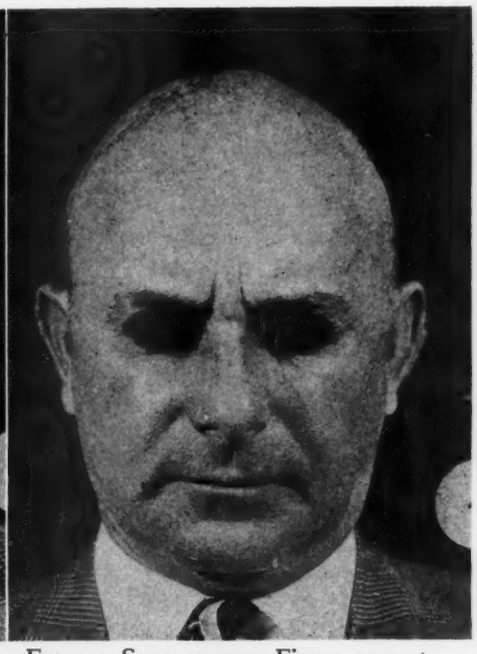

Fig. 10. Same case as Figure 9; postoperative.

Technic. Tantalum is serviceable for the repair of facial and cranial defects of all sorts, and can be used in a one-stage technic. A moulage of the defect is first taken; and on this, the repair is built up with wax. From this model, a die and a counter die are made. The tantalum plate is made and pressed out. Little additional modelling or trimming is necessary to make the plate fit.

Patients with contour defects of the face, especially if war casualties, invariably have a greal deal of scar tissue. This scar tissue should be excised through the original laceration. A new incision extending through the old laceration should be avoided if possible to prevent future necrosis of some skin flap. Strict hemostasis is essential because an infected hematoma cannot be evacuated without sacrificing the plate.

Facial Defects. The use of tantalum for facial defects has not, so far as I know, been previously reported. However in battle wounds and other injuries of the face, where portions of the orbital rim or zygomatic arch are lost, tantalum plates can be made that will accurately reproduce the facial symmetry. In repairing an orbital rim or zygomatic defect, the tantalum plate is anchored at three points like a tripod. These sites are determined in advance. In the laboratory, perforations are made to hold the tantalum wire for fixation. I usually make additional perforations at the approximate anchor site to avoid the necessity of drilling these in the operating room. Nevertheless, an electric dental drill should be part of the sterile operating kit. Holes, one quarter of an inch

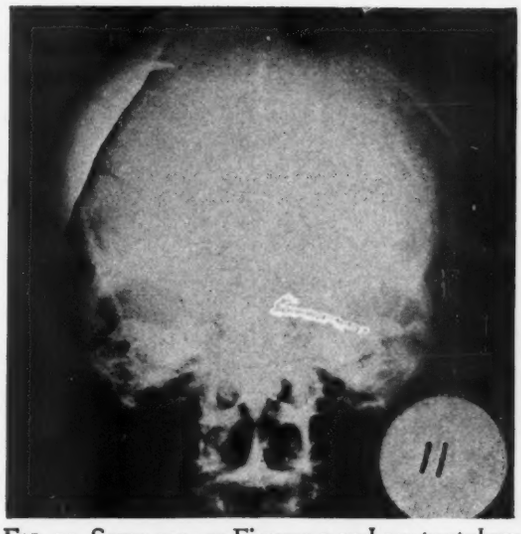

Fig. 11. Same case as Figures 9 and 10; tantalum plate in place.

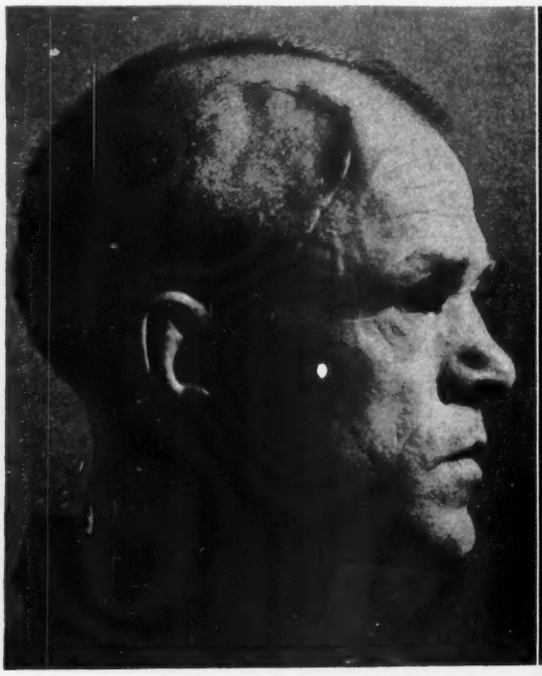

Fig. 12. Cranial defect; preoperative.

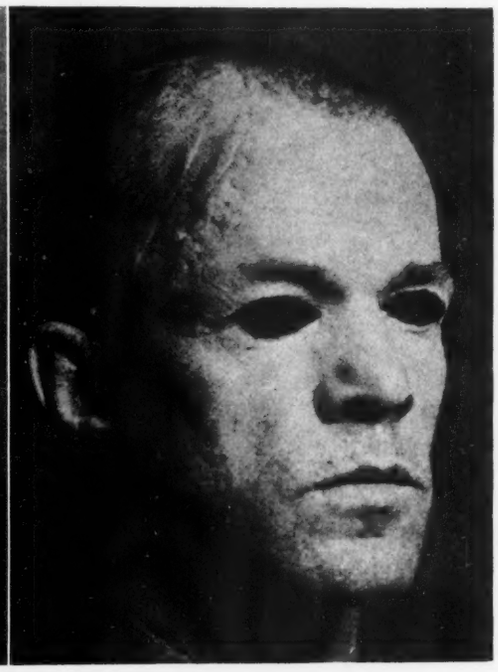

Fig. 13. Same case as Figure 12.

in diameter are made in the plate to allow for drainage. Figures 1 to 8 illustrate the methods and results.

Cranial Defects. When cranial defects are being repaired with tantalum, the skull is wedged, the plate fitted in, and a small triangle (similar to a glazier's triangle) is hammered in between the two layers of bone to hold the plate fast. (Figs. 9 to 14.) Sometimes, after a tantalum plate is inserted into a skull, the operator finds serum or blood under the flap overlying the plate. This is treated by tapping every other day, or daily if necessary. Tapping is done under strict asepsis. An elastic compression bandage is then applied over a sterile dressing.

Disadvantages. Some patients complain that they experience a little pain in the overlying skin during excessively hot or cold weather. This is the only objection made by patients to tantalum repairs.

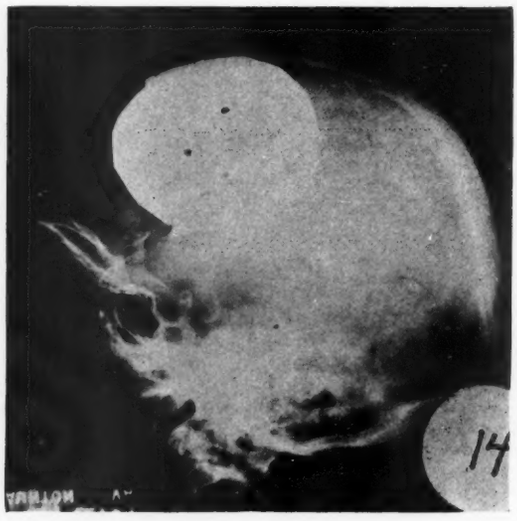

Fig. 14. Same case as Figures 12 and 13; postoperative roentgenogram.

STRICTURES FOLLOWING TRANSURETHRAL RESECTION

COMMENTS ON THE INDICATION FOR THE OPERATION

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MOST of the strictures following transurethral resection occur in cases that have been resected with a Braasch Bumpus or a Thompson cold punch. These instruments are cold and would injure the urethra only by friction and trauma. Friction and trauma may be caused by one or more of the following factors: not enough room in the urethra for the instrument; insufficient lubrication; too many movements of the instrument sliding through the urethra; or rough grasping of the instrument while forcing the piece to be removed into the slot, thus increasing the friction and trauma by added pressure against the wall of the urethra on the side the bite is taken. Furthermore, when the triangular ligament is used as a fulcrum, while forcing the piece to be resected into the slot of the instrument, the mucous membrane lining of the urethra at this point is subjected to even greater pressure.

Pursuing this line of thought further, with the hope of evaluating these separate factors, the number of movements executed during an operation for prostatic obstruction was counted and recorded in fifteen cases, at clinics where the cold punch was used entirely, and also at clinics where the electric loop only was in use. The counting and recording was done with the aid of a Veeder-Root hand tally while these transurethral prostatic resections were done by experts in whose hands, "every little movement has a meaning all its own." Most urologists are not so highly skilled as these men in this particular phase of urology; therefore, generally, the number of movements would be greater, whenever a complete removal of the gland is attempted.

Recording the movements of the instrument during the resection of small, medium and large prostates, at several different clinics, the author found, by actual count, that the number of movements with the McCarthy resectoscope and the Thompson punch instrument is about the same during orientation, the observation of the progress of the operation, and the stopping of hemorrhage. However, actual removal of the condemned area is attended with no movement that could cause injury to the urethra when the McCarthy instrument is used; but in the punch operation several things happen which may result in trauma. When removing tissue with the Braasch or Thompson punch, the instrument is shoved forward so that the slot is over the doomed area. Then, either by a pump-like action, using the triangular ligament as a fulcrum, or by sheer strength, the tissue to be removed is forced into the slot by pressing the instrument against the area to be resected. Maintaining this pressure, the tubular knife or punch is shoved home. The piece thus excised usually sticks to the instrument, obscuring the vision; in order to get rid of it the instrument is shaken vigorously.

By adding these biting and shaking movements to the movements concerned with the orientation and examination of the operative field in general, the progress of the operation, and the control of hemorrhage, one gets an idea of the chance for injury to the sensitive urethra.

The removal of one large prostate showed, on the tally counter, 2,000 movements; another case obstructed by a relatively small prostate recorded 750; while most cases were medium sized to large glands entailing from 1,000 to 2,000 movements. In the use of the two types of

instruments, then, the number of movements involved in the resection of a large gland compares as follows: McCarthy instrument—1,000 to 2,000 movements; punch instrument—1,000 to 2,000 movements, plus 150 to 250 times when great pressure is exerted against the wall of the urethra in the act of punching out tissue, plus 100 to 200 times when the instrument is shaken to rid it of the punched out tissue in order to clear the view.

Although the punch operation leaves live tissue and the electric loop a coagulated surface of devitalized tissue, the authors have seen more strictures following the cold punch method. This may be due partly to the preponderance of cases subjected to the punch operation over those done by the McCarthy method in this part of the country. However, the main reason is undoubtedly the fact that there is so much added chance of injury to the urethra during the actual removal of tissue, as described above, when the cold punch is used.

CASE REPORTS

Case I. A. A., a white male, aged sixty-one, came to the hospital on March 19, 1943, complaining of inability to pass his urine. He gave a history of having been resected at a famous clinic with a Thompson resectoscope, one and a half years previously. For the past six months, he had noticed that his urinary stream was becoming smaller and smaller. An unsuccessful attempt was made to pass a catheter. There were strictures at the meatus, one inch proximal, and at the junction of the anterior and posterior urethra. A fine filiform was passed after several attempts. Followers, up to 18 F. were passed, but the scar would not yield beyond that. The patient was advised to have his strictures treated; however, as he feared all transurethral procedures, and as he could now pass his water better, he refused all further treatment. His strictures were undoubtedly due to the transurethral resection done one and a half years before, because, had they been present at that time, the resectoscope could not have been passed.

Case II. E. R., a white male, aged sixty-eight, was referred on May 14, 1944, by a general surgeon. He gave a history of having had a transurethral prostatic resection done with the punch instrument in 1938. He had noticed a progressively diminishing urinary stream. Physical examination showed the man in good general condition, but with a stricture at the meatus, another two inches proximal, and a third at the junction of the anterior and posterior urethra. The meatus admitted a No. 10 F.; the next stricture, a No. 8 F.; and the third, only the finest filiform. His residual urine was 600 cc. Prostate was enlarged, grade 2. There was no evidence of cancer. On May 16, 1944, under gas anesthesia, filiforms and followers, followed by sounds, were passed, dilating the strictures up to No. 22 F. Then a perineal prostatectomy[10] was done. Prostatic tissue removed measured 3 cm. by 5 cm. by 3 cm. Pathological diagnosis was "adenomatous hypertrophy of the prostate." This man was treated postoperatively as a case of traumatic urethral stricture.

Case III. B. G., a white male, aged sixty, came in on October 15, 1945, with a history of having had a transurethral resection done six months previously. For the past month he had noticed a narrowing of his urinary stream until it had become a mere dribble. On questioning, it was brought out that he had heard, during the operation, only a buzzing noise; so he was undoubtedly resected with a McCarthy resectoscope. On examination, it was found that only a filiform could be passed into the bladder. The strictures, one two inches from the meatus, and one at the prostatic urethra, were very dense and hard to overcome. However, this man has been unusually cooperative, and at present the results are very good. Nevertheless, he will have to be watched carefully and to have sounds passed at regular intervals for the rest of his life.

These strictures would not occur if transurethral operations were done *only on selected cases*. Whenever a 30 F. sound does not pass easily; when the resectoscope passes in but seems to be grasped or held snugly by the urethra; when the prostatic urethra is abnormally long due to enlargement of the prostate; and when a short suspensory ligament makes it difficult or impossible to do a resection without applying great pressure with the instrument

against the mucous membrane of the urethra; it is better to do a conservative perineal operation or a suprapubic enucleation. However, should the patient's general condition demand a transurethral, even if one or more of the above listed contraindications exist, it should be done through an external urethrotomy. Nesbit[6] strongly recommends this procedure; Creevy and Webb are using it frequently; and the Mayo Clinic recommends its use wherever indicated.

Recently, in an excellent article, Orr, Kindert and Pyle[7] stated that it is a mistake to consider that the average urethra will easily accommodate a No. 28 F. resectoscope. Middleton[4] says that since he has used an external urethrotomy where the urethra was snug to a No. 28 F. sound, postoperative strictures have been "transformed from a bugbear to a memory."

The proponents of the different methods of treating prostatic obstruction have for years maintained their belligerent fronts, and at intervals have written articles[11] bristling with intolerance. Emmett,[3] recently, revealed a soft spot in his strongly fortified "front" when he said, "I have no quarrel with the surgeon who finds it the best procedure to care for eighty-five per cent of enlarged prostate glands by transurethral resection and fifteen per cent by open operation." This statement is pregnant with tolerance and good sense. Surely, in every doctor's practice, from general practitioner to specialist in urology, there will be from 15 to 25 per cent of the cases presenting themselves with prostatic obstruction who would be better off if cared for in the manner mentioned by Emmett and definitely outlined in this paper, rather than in the "run of the mill" manner which the larger clinics of this country are using at the present time.

There is a definite need for all three methods of operation for the relief of prostatic obstruction, and the three methods should be used in the following manner:*

I. Suprapubic. (A) All cases of grade 4 enlargement who are from fair to good risks, and in whom there is no suspicion of cancer.* By this method, with a benign enlargement, the time on the operating table can be very short;[8] while a complete removal of a large gland transurethrally cannot be done in less than one hour by most resectionists. Such a long time on the operating table is undesirable, and the removal of so much tissue involves 1,500 to 2,000 movements of the transurethral instrument. With the punch instrument another 250 bites and 200 shakings of the instrument must be added, increasing the probability of injury to the urethra.

Case IV. N. T., a white male, aged sixty-four, presented himself, on February 13, 1945, with a history of having always been in good health except for the last two years, when he had had symptoms of increasing urinary obstruction. Physical examination showed the man in good general condition. Urine was clear. There was 500 cc. residual urine. The prostate was enlarged, grade 4, judged by rectal examination and the length of the prostatic urethra. Suprapubic prostatectomy was done on February 14, 1945. A Foley catheter was placed in the urethra with the bag injected to 20 cc. and pulled into the prostatic bed. Convalescence was uneventful. The Foley catheter was removed on the ninth day, at which time the suprapubic wound was dry. The patient passed his water normally and went home on the eleventh postoperative day. A letter from him two months later says, "I am sixty-five years old today and in good health. My waterworks functions fine and the world looks brighter."

Case V. O. L., a white male, aged fifty-eight, came in on January 16, 1945. He gave a history of good health up to two years ago, when he began having to get up at night to pass his water. The doctor, by whom he was referred, had found it necessary to catheterize him on

* T. Millin,[5] working in London, recently reported twenty cases of Retropubic prostatectomy, going through the prevesical space, the gland being attacked distal to the bladder. He says that this method "bids fair to supplant" those now in use.

* Enucleation is difficult in the presence of cancer, and a cure cannot be expected unless the capsule is also removed; the operation is prolonged, and the bladder may be torn loose, increasing chances of shock, hemorrhage and infection.

several occasions. Physical examination showed the man in good general condition. Residual urine measured 300 cc. The prostate was enlarged, grade 4, judging from rectal examination and the length of the prostatic urethra. There were no nodules felt by the examining finger, and the gland was not fixed. The urethra accommodated a 30 F. sound. The patient was advised to have a suprapubic prostatectomy done, but the operation was refused; a transurethral resection was demanded. He was told that more than one resection would be necessary with such a large gland, and that his hospital stay would be much longer; but fear of the old suprapubic operation was strong enough to override common sense in submitting to his doctor's advice. On January 19, 1945, a transurethral resection was done using the McCarthy resectoscope. Considerable bleeding was encountered, and only 30 Gm. was removed from 12 to 4 clockwise, and from 12 to 8 counter-clockwise. A Foley catheter with a bag inflated to 30 cc. was left in the bladder. One week later, the main mass of the gland was removed; bleeding at this stage was moderate and easily controlled. A Foley catheter was placed in the bladder as before. It was removed two days later, but the patient could not urinate. The catheter was reinserted and each day removed to see if the patient could pass his water, but without success; so, one week following the second stage, a third resection was done and 30 Gm. more tissue was resected. Two days later, the catheter was removed and the patient passed his water normally. He went home on the 24th day after his admittance to the hospital. He was still running a temperature of 100°F. in the afternoons, and he had considerable pus in his urine. One month after leaving the hospital, his urine was still slightly cloudy. It cleared up about six weeks after he arrived home.

If the patient in Case v had been treated in the same manner as the one in Case iv, their postoperative courses would most likely have been practically identical. In the future, patients like the one in Case v will be advised to have a suprapubic prostatectomy done, since this, as in Case iv, is definitely the operation of choice. Should the patient insist on transurethral resection, as many will do because of the operation's publicity, he will be referred to a place where transurethrals are done exclusively.

II. Perineal. (A) All cases of early cancer in whom a worth while percentage of cures may be expected by the removal of the entire gland, including the capsule.

Case vi. E. W., a white male, aged seventy-six, presented himself on July 6, 1943. He gave a history of urinary difficulty extending over the last four years, but for the last month, his family physician had been forced to catheterize him several times. Physical examination showed him in good general condition. His blood pressure was 150/80. Urine was clear with a specific gravity of 1019. It contained albumin but no sugar. Microscopic examination showed no red blood cells, but a few leukocytes. Blood examination showed 92 per cent hemoglobin. Nonprotein nitrogen was 22.9 mg., and creatinine was 1.5 mg. per 100 cc. of blood. Wassermann was negative. On rectal examination, an enlarged gland containing several hard nodules was felt. The gland was not fixed in the pelvis, but could be moved by the palpating finger. A diagnosis of early cancer was made and a radical perineal operation was advised and accepted. This was done on July 8, 1943. The prostate, with capsule intact, was removed. A Foley catheter was passed through the urethra and into the bladder. No effort was made to suture the urethra to the bladder, and no special invitation was extended to the colon bacilli around the anus by inserting a drain. Sulfa crystals were placed in the wound as it was closed. Dead spaces were obliterated and all bleeding controlled. The wound was closed tight using a subcuticular stitch so as to leave no extra holes in the skin, and a dressing of collodion with sulfa crystals was applied. The Foley bag was injected with 75 cc. water and a gentle pull was maintained for six hours with the aid of a rubber band from the catheter to adhesive around the upper end of the tibia. The catheter was left in situ for fourteen days. The microscopic pathological diagnosis was cancer, grade 2. On the seventeenth postoperative day, the patient left the hospital. He had no difficulty in passing his water and had good sphincter control. He was given stilbestrol, 1 mg. daily. He was treated postoperatively as a case of traumatic stricture. Unfortunately, this man died later of metastasis.

The authors regret that they have no case of cancer of the prostate to report in whom they have obtained a cure; however, several men[1,11] doing a greater number of radical perineals for cancer have reported varying percentages of cure.

(B) All cases in which cancer is not suspected and which are judged to be from fair to poor risks, but in whom some contraindication to transurethral resection exists. In such cases a conservative perineal operation[10] is the operation of choice.

Case VII. An internist had been treating J. L., aged fifty-five, for nephritis, cardiac insufficiency and high blood pressure. Upon finding a large prostate and residual urine of 500 cc., he referred the patient with the request that the prostatic obstruction be corrected. On May 2, 1945, his blood pressure was 225/125; blood chemistry showed non-protein nitrogen 20, creatinine .6; blood count showed 4,200,000 red blood cells, 8,000 white blood cells, hemoglobin 85 per cent; urinalysis showed albumin 1 plus, sugar 0, specific gravity 1020. The prostate was enlarged, grade 3, with no evidence of cancer. The small caliber of the anterior urethra made it impossible to pass a resectoscope. If a resection were to be done, it would have to be done through an external urethrotomy. Because the patient's blood pressure was so high and the gland was so large, the operation would have to be done in two stages; bleeding would necessitate so much attention that enough tissue could not be resected in the allotted time. However, a two-stage resection in such a case would mean reentering through the urethrotomy wound with chances of stricture of the urethra following. Therefore a conservative perineal enucleation, as mentioned above, was considered the operation of choice. This was done on May 8, 1945. Recovery was uneventful.

III. Transurethral. (A) All cases of obstruction due to moderate enlargement of the prostate[8] in which the caliber of the urethra is 30 F., and in whom there is no suspicion of early cancer.

Case VIII. C. S., a white male, aged fifty-five, came in on May 15, 1945, complaining of inability to pass his water at times. He gave a history of having had to be catheterized on several occasions. Upon examination he was found to have 200 cc. residual urine; on rectal examination, a slightly enlarged gland with no hard nodule was found; on cystoscopy, an enlarged median lobe was seen. He was advised to have a transurethral resection, which was done on May 24, 1945.

(B) All cases of advanced cancer of the prostate.*

Case IX. A. J., aged seventy-four, presented himself on January 4, 1945, giving a history of progressive urinary obstruction, with some recent sciatica. Physical examination showed the man in good general condition. His blood pressure was 150/90; urine was clear and negative for albumin and sugar. There was 300 cc. residual urine. On rectal examination a large prostate, grade 4, was found, frozen in the pelvis. A diagnosis of advanced cancer of the prostate was made. A transurethral resection was advised and accepted. On January 8, 1945, under spinal anesthesia, 90 Gm. of tissue was resected with the McCarthy resectoscope. Convalescence was uneventful. The microscopic pathological diagnosis was "adenocarcinoma, grade 2." He left the hospital on the eighth postoperative day and was given stilbestrol, 1 mg. daily. One month postoperatively, his urine contained many pus cells, but he had no sciatica. Two months after the operation, the urine was clear. A letter from him, dated April 7, 1945, says, "I have no pains whatsoever and am feeling fine."

(C) Poor operative risks, including those whose glands may be very large but who would be safer under repeated resections than if done by the conservative perineal method.

Case X. M. B., a white male, aged eighty-four, presented himself on May 2, 1945. He complained of frequent urination which disturbed his sleep. On examination his residual urine was found to be 400 cc. Urinalysis showed: specific gravity 1010; albumin 2 plus; sugar 0. His blood chemistry showed non-protein nitrogen, 40; creatinine .6; 5,000,000 red blood cells; 10,000 white blood cells; hemoglobin 90 per cent. Since the caliber of his urethra was adequate, he was advised to

* Stilbestrol and castration have been found of definite value, especially in relieving pain.

have a transurethral resection, which was done on May 4, 1945. Two days later, the catheter was removed and he passed his water freely. On May 8, he had a cerebral hemorrhage which paralyzed his left arm and leg. Recovery was partial and he left the hospital after three weeks.

When a transurethral seems to be the operation of choice, but some anatomical contraindication exists, external urethrotomy (which in itself may result in urethral stricture) must be added to transurethral resection. With this in mind, the case must be reviewed. The advantages and disadvantages of each method should be weighed. Using his best judgment, common sense and honesty,* the surgeon should decide upon the type of operation best suited for the case at hand.

The object of this paper is to call attention to the enormous traffic in the urethra during transurethral resection, and also to point out to the reader that there are *definite* and *important* indications for the employment of each one of the three methods of operation for the relief of prostatic obstruction. It is high time to dispel the myth which prevails in certain parts of the United States, but nowhere else in the world, namely, that all prostatic obstructions can and should be handled in the same manner.

One is reminded of the controversy concerning the treatment of peptic ulcer which raged twenty-five or thirty years ago, when some men claimed that all peptic ulcers should be treated by performing a gastroenterostomy: while another group of men, equally insistent, treated all such cases medically. A little later, certain European clinics recommended gastric resection as applicable in all cases. Each one of these three methods of treatment has long since found and occupied its respective place in the treatment of peptic ulcer. The controversy concerning the treatment of prostatic obstruction is analogous. There are three different types of treatment. The claims for each type are just as insistent. And, as in the case of peptic ulcer, each type of treatment will assume its logical place in the management of prostatic obstruction, contingent upon the clinical entity at hand, and not upon the geographical location of the urologist.

* Urologists of fame have stated that the operation of choice is the one in which the individual operator is most adept. Although this is true to a certain extent, it does not consider the patient entirely; it might be better to refer him to another surgeon who is more skilled in the type of operation which best suits the needs of this particular patient.

SUMMARY AND COMMENT

The occurrence of strictures of the urethra following transurethral resection seems to be increasing.

With a Veeder-Root Hand Tally counter, the movements of the instrument within the urethra in transurethral resection have been counted, revealing an astounding number of such movements.

This study also shows that resection by the punch method, as compared with the McCarthy method, is accompanied by added trauma due to the bites and the shakings necessary, as well as to the increased pressure applied in the removal of tissue with this instrument.

The need for a choice of operation to fit each individual case is stressed. It goes without saying that the urologist of the future, doing prostatic surgery, will have to have training enabling him to do suprapubic, perineal and transurethral operations equally well; so that his judgment of which operation is indicated in each individual case will not be hampered by the fact that he has had special training in doing perineal operations; or that he is a general surgeon and only trained to do the suprapubic operation; or by the fact that his intensive training in transurethral surgery has made him into a mere resectionist.

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When strictures of the urethra cannot be treated by dilatation, or when quick results are desirable, internal urethrotomy is indicated. This operation is not to be attempted when an instrument cannot be passed through the stricture.

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Case Reports

SOLITARY PYOGENIC ABSCESS OF THE LIVER

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HEPATIC abscess may be divided into two groups: (1) Amebic, which is by far the largest group and (2) pyogenic. This latter group may be divided into two subheads (a) multiple liver abscesses and (b) solitary liver abscesses. The subject of the solitary pyogenic liver abscess will be considered in this paper and three cases reported.

CASE I. A colored male, age twenty-five, was admitted to the hospital with generalized peritonitis on July 16, 1941. The patient had been sick with abdominal pain, nausea and vomiting, and loss of appetite for several days before reporting to the hospital. As there were no signs of localization of the process and the patient's general condition was good, the abdomen was opened and a gangrenous ruptured appendix removed on the date of admission. The abdomen was drained through a stab in the right lower quadrant.

The patient had a stormy postoperative course. Wangensteen suction was used continuously and intravenous fluids given. The patient had a fever of 101°F. to 99°F. for nine days postoperatively, then for several days he showed improvement and had a temperature of only 99°F. Following this, the temperature again went to 100°F. and 101°F. and on the twenty-first postoperative day he had a chill and the fever rose to 103°F. The patient complained of mid-abdominal pain at this time. By the twenty-third postoperative day there was c-v angle tenderness and the fever remained at 103°F. A diagnosis of liver abscess was made clinically on the twenty-fifth postoperative day. Fluoroscopy revealed an elevated right hemi-diaphragm with approximately one-third limitation of motion of the right hemi-diaphragm as compared to the left. On the twenty-sixth postoperative day an *x*-ray film showed elevation of the right diaphragm and the following day a further increase in elevation.

On August 13, 1941, the twenty eighth postoperative day, the patient became worse with marked restlessness, pain in the right upper abdomen at the anterior auxillary line, nausea and vomiting. The temperature was 103°F., pulse 100 and respiration 24, with a cough suggestive of diaphragmatic irritation. The abdomen was explored through a right paracostal incision and the right lobe of the liver was found to be greatly enlarged upward with many fine adhesions between it and the diaphragm. Drains were inserted to promote formation of adhesions with walling off of the process from the peritoneal cavity. The wound was closed loosely around the drain. On August 16, 1941, three days after surgery, the abscess ruptured spontaneously and drained a large amount of yellow pus through the paracostal incision and no further surgery was needed. Bacteriological studies were not done. On August 8, 12, 20 and 30, 1941, 500 cc. whole blood transfusions were given. The patient had a high temperature for seventeen days following drainage of the abscess, then became afebrile and was out of bed in a wheel chair on the twenty third day after operation for drainage of the liver abscess. Chemotherapy with intravenous sodium sulfathiazole was started two days before the operation for exploration of the liver and continued for ten days postoperatively. A total of 28 Gm. was given over this period. The patient was discharged cured on September 28, 1941, after regaining his normal weight. He was examined one year later and was in good health.

CASE II. A white male, age thirty-eight, was admitted to the hospital September 22, 1944, with the following history: the patient was feeling well until 6:00 A.M. on the day of admission when he was awakened with a shak-

ing chill. This was followed by fever, weakness, nausea and vomiting. The nausea and vomiting were not marked. On the way to the hospital, he developed a "catchy" pain under the right rib margin associated with deep inspiration and coughing. This pain was present for only a short time and then disappeared. He had a slight cough for the past twenty four hours which was not productive of sputum. For the past one month he had occasional dull pain in the right shoulder uninfluenced by movement of the shoulder but aggravated by carrying anything for a long period of time. The remainder of the history is unimportant.

Examination revealed a well developed and well nourished white male who appeared to be acutely ill with a temperature of 103°F., pulse 116 and respiration rate of 26. Positive findings on examination: dullness over the lower lung with diminished breath sounds and occasional crepitant rale throughout this area. Examination of the abdomen: liver dullness, seemed to be enlarged upward on percussion but the liver was not palpable. The spleen was palpable. The white blood count on admission was 11,400 with 74 per cent segments. A diagnosis of right lower lobar pneumonia was made. *X*-ray film of the chest on admission: marked doming of the right diaphragm in the mid-portion, raised 1½ interspaces above its normal position. No lung pathology visualized. Repeat films on the 25th and 30th showed little change from the original film. A diagnosis of liver abscess was made and the patient given a course of emitine hydrochloride with no symptomatic improvement. Stool examinations were negative for endamoeba histolytica. The patient's condition gradually became worse with marked loss of weight and strength. A continued septic type temperature occurred. During this same period, he was given a course of sulfadiazine, 1 Gm. every four hours for three days, and penicillin therapy was begun on October 1, 1944. It was continued through October 16, 1944, in doses of 30,000 Oxford units intramuscularly every three hours.

On October 3, 1944, the patient was operated upon and the abdomen explored through a right paracostal incision. A decision to operate through a right paracostal incision was made because the mass on the dome of the right lobe of the liver pointed anteriorly and it was not believed practicable to attempt to reach the abscess by means of the Ochsner-Nather extra serous retroperitoneal approach. On exploration through the right paracostal incision, the gallbladder was moderately distended and contained a large stone. The organ was normal in appearance otherwise. The liver was enlarged one to two finger breadths below the costal margin. There was a soft mass in the liver substance on the anterior-superior aspect of the right lobe of the liver with many fine adhesions between the liver and the diaphragm. Several large vaseline gauze packs were inserted to the mass and around the lower margin of the liver in an attempt to stimulate production of adhesions with walling off of the disease process from the peritoneal cavity. The wound was then closed loosely around the packs.

Under sodium pentothal anesthesia on October 6, 1944, the original paracostal wound was reopened and on exploration inadequate walling off of the disease process by adhesions was found. The abscess cavity was carefully aspirated and about 30 to 40 cc. of thick greenish pus was removed. The abscess cavity was then filled with 10 cc. of sterile water containing 20,000 Oxford units of penicillin. Fresh vaseline gauze packs were then placed around the edge of the liver and down to the disease process. Crystalline sulfanilamide, 10 Gm., was sprinkled throughout the involved area and the wound again closed loosely around the packs. Following this procedure, there was marked clinical improvement and the patient became free of fever and was allowed out of bed four days following the second operation.

Cultures of the pus from the liver abscess isolated beta hemolytic, coagulose positive, staphylococcus aureus.

On October 8, 1944, the patient developed mild jaundice which persisted for several days and then cleared up.

On October 14, 1944, under sodium pentothal anesthesia, the paracostal incision was again reopened in the lower portion and exploration revealed adequate adhesions walling off the abscess from the peritoneal cavity. The soft mass on the dome of the right lobe of the liver was still present. An attempt was made to aspirate the abscess but nothing was obtained. The abscess was easily opened by blunt dissection with the finger and several cc. of bloody serous fluid escaped. This material

was clear and odorless. No pus was present. A Penrose drain was inserted in the abscess cavity and brought out through the lower end of the paracostal incision. The gauze packs were not disturbed. The wound was closed loosely around the packs and the drain with through and through sutures. Crystalline sulfanilamide was sprinkled in the wound and the abscess cavity before closing. The patient improved rapidly following this and was ambulatory on the second day following the third operation.

On October 19, 1944, the vaseline gauze packs and Penrose drain were removed under sodium pentothal anesthesia. The wound healed slowly and required secondary closure with stainless steel wire sutures.

Following the third operation, the patient developed a pleural effusion which required tapping once on October 26, 1944. This patient was early ambulatory after surgery and his general condition remained good, although a persistent fistula developed which drained for several weeks.

Case III. A white male, age 26, was admitted to the hospital on December 25, 1944, complaining of pain in the epigastrium and upper left quadrant of the abdomen, chills and fever. The patient gave a history of being well until December 5, 1944, when he had a sore throat and chilly sensation and felt malaise with pain in the left upper quadrant of the abdomen. He was treated in another hospital for two weeks and discharged in good condition. Shortly after leaving the hospital he started on a trip across the United States by train and noticed during the trip a persistent dull pain in the "pit of his stomach." This pain became gradually more severe and was prominent in both the epigastrium and left upper quadrant. At the onset of the abdominal pain he had pain in the lower part of his chest on inspection. He had no cough and no nausea or vomiting prior to entering this hospital. On admission he complained of some pain in the chest on deep inspiration. The patient gave no history of diarrhea or bloody stools in the past.

Examination revealed a well developed and well nourished white male who appeared acutely ill with a temperature of 102°F., pulse 100 per minute and respiratory rate of 20 per minute. Positive findings on examination were: marked pallor of fascies, slight lag of expansion on left side of thorax during respiratory cycle, scaploid abdomen with exquisite tenderness and muscle splinting over the epigastrium and upper left quadrant of the abdomen. An impression of a mass in the epigastrium was given but because of the muscle rigidity and extreme tenderness the examination was unsatisfactory. The white blood cell count was 17,000 with 86 per cent neutrophiles, the red blood cell count was 3,750,000 and the hemoglobin was 65 per cent. Stool examination for endamoeba histolytica was negative. The icteric index was 3.9. The urine and smears for malaria parasites were negative. *X*-rays of the chest revealed fuzzy irregularities of both diaphragmatic contours with neither costophrenic angles sharply outlined because of slight effusion. Scout films of the abdomen were negative. Fluoroscopic examination of the chest revealed a high semi-fixed right diaphragmatic leaf as compared with the left. After receiving a 1000 cc. transfusion of whole citrated blood the patient was operated on. The abdomen was opened through a high right rectus splitting incision and a large mass to the left of the mid-line was found. This mass was the left lobe of the liver which was firmly adhered to the parietal peritoneum of the anterior abdominal wall. The remaining viscera were normal. Five Gm. of crystalline sulfanilamide were sprinkled in the peritoneal cavity, the incision closed and a firm dressing applied. A small incision was then made to the left of the mid-line and directly over the left lobe of the liver. This was carried through the abdominal wall and a large abscess cavity entered. Thick yellowish pus escaped. Soft rubber dam drains were then inserted into the abscess cavity after injecting 15,000 Oxford units of penicillin into the cavity (patient had received 30,000 Oxford units of penicillin intramuscularly for forty-eight hours prior to surgery and this was continued postoperatively for several days).

Smears and cultures from the abscess taken at the time of operation were sterile. A piece of the abscess wall was examined by the pathologist microscopically and a report of granulation tissue was made.

The wound drained moderately for eighteen days and then closed. The patient gained strength rapidly and on the fourth postoperative day his temperature became normal

where it remained. He was discharged from the Surgery Department in good condition on January 22, 1945. Two months later the patient was in good condition with both wounds healed.

Incidence. Ochsner and Debakey[1] reported 186 cases of liver abscesses over a period of ten years of which 139 were amebic and forty-seven pyogenic. Of the latter group 54.5 per cent were considered solitary pyogenic liver abscesses. In their large collected series of cases of liver abscesses only 28.8 per cent were solitary pyogenic abscesses. Eliason[2] and co-workers reported a series of forty-seven cases of pyogenic liver abscesses of which fifteen were of the solitary variety. During a ten-year period at Charity Hospital in New Orleans, Louisiana, Ochsner and Debakey[1] point out that out of 540,776 admissions there were only forty-two cases of pyogenic liver abscesses including both single and multiple abscesses. According to most authors the incidence is greater in males. In Ochsner's and Debakey's[1] series of pyogenic abscesses which include both multiple and solitary, thirty-three were in males and fourteen in females. In Rothenberg's and Linder's[3] series of twenty-four cases of solitary pyogenic liver abscess seventeen were in males and seven in females. Eliason and co-workers[2] report in their series of forty-seven cases of both multiple and solitary liver abscess an incidence of thirty males and seventeen in females.

There seems to be no racial difference according to most writers on the subject of both types of pyogenic abscesses of the liver.

Thus we see that hepatic pyogenic abscess of the solitary variety is not common. Most authors on the subject of pyogenic abscess of the liver fail to separate the multiple from the solitary, thus it is difficult to obtain true figures on this condition.

Etiology. Most authors state that appendicitis is the cause of pyogenic liver abscess in the majority of cases. Ochsner and Debakey[1] state that of their series of both multiple and solitary abscess of the liver only five cases or 10.6 per cent were due to appendicitis. Rothenberg and Linder[3] were able to determine the cause in only two and probable cause in a third case of their series of twenty-four solitary abscesses. Of the two with known cause, one was due to ruptured peptic ulcer, another due to cholecystitis, and the third or probable case followed an attack of appendicitis that was operated twenty-six weeks before the onset of the symptoms of disease of the liver. These authors stress hematogenous spread from a focus of infection such as a carbuncle or tonsillitis as being the source in most cases of solitary abscess of the liver. Eliason and co-workers[2] in their forty-seven cases of pyogenic abscess state that 49 per cent were due to appendicitis. These authors quoted, with the exception of Rothenberg and Linder,[3] do not break their series down into the multiple and the solitary group, thus their figures are at variance with Rothenberg and Linder.[3] The causes of pyogenic liver abscess as listed by various writers who include both types of pyogenic abscesses together are as follows:

1. Appendicitis
2. Cholecystitis
3. Gangrenous hemorrhoids
4. Ruptured peptic ulcer
5. Trauma, penetrating and non-penetrating
6. Proctitis and sigmoiditis
7. Diverticulitis
8. Ulcerative cancer of the bowel

The cause of solitary liver abscess is often obscure. Even in the reports in the literature in which both multiple and solitary abscesses are lumped together the percentage of cases of unknown cause is high but whether this high percentage is due to the solitary or the multiple is not stated. In the experience of most authors, the cause of multiple liver abscess is often obvious, therefore, one assumes that the high percentage of unknown cause is probably due to the group of solitary abscesses

included in each series. Ochsner and Debakey[1] in their forty-seven cases of both types, of which 54.5 per cent were solitary, could not account for 59.5 per cent as to causes. Eliason and co-workers[2] were unable to account for twelve out of their series of forty-seven of both types which included fifteen solitary abscesses. One of the cases in this report followed a ruptured appendix with generalized peritonitis. The second case was probably due to a low grade cholecystitis and the cause of the third case could not be determined. In the second case there was no history of gallbladder disease but the gallbladder contained a large stone. Rothenberg and Linder[3] state that liver abscess is rarely preceded by cholecystitis whereas Ochsner and Debakey[1] found cholecystitis to be the cause in 6.3 per cent of their cases of pyogenic liver abscess but do not state whether these were solitary or multiple.

Bacteriology. The most common organisms found are the streptococci, staphylococci and bacilli coli. In eleven of Rothenberg and Linder's[3] forty-seven cases of solitary abscess of the liver the pus was sterile. Out of twenty-nine of Ochsner's and Debakey's[1] forty-seven cases of both types that were studied bacteriologically eleven were sterile. Other organisms reported by Williams and co-workers,[4] Rothenberg and Linder,[3] Eliason and co-workers[2] St. John and co-workers,[5] and Ochsner and Debakey,[1] are: Aerobic hemolytic streptococci, anaerobic hemolytic streptococci, non-hemolytic streptococcus aureus, non-hemolytic staphylococcus albus, Bacillus coli, pneumococcus, Bacillus subtilis, faecallis, alcaligenes, diphtheroids, mucosus capsulatus, pyocyaneus, aerogenese capsulatus, typhosus, lephthrix, streptothrix, salmonella, spirochetes and gonococci. In Case I in this report no bacteriological studies were done. In Case II beta hemolytic staphylococcus aureus was isolated and in case III the pus was sterile.

Pathology. Infection of the liver may take place through the following routes in order of their importance in solitary liver abscess: Hepatic artery and vein, portal vein, bile ducts, direct extension and lymphatics.

The first four routes are the most common although the relative importance of each is difficult to determine from statistics in the literature on the subject because of multiple liver abscesses being included in the same series with the solitary type. Rothenberg and Linder[3] have pointed out the importance of the first and believe it is the route in those cases of undetermined origin. Suppurative appendicitis is a common cause of pyogenic abscess through the portal vein but its frequency probably has been overemphasized. Since appendicitis is more often the cause of multiple abscess formation in the liver rather than solitary abscess, statistics on the cause and pathogenesis of liver abscess which include both types are misleading.

This process occurs through thrombophlebitis of appendicial vessels with passing of infected emboli to the liver or progressive phlebitis spreading up the portal vein. Similar infection in the portal vein system can cause abscess by infected emboli. One of the patients in this report developed an abscess of the liver through the portal vein and the second abscess probably developed through an infection in the biliary system.

Ochsner and Debakey[1] place infection from the gallbladder in the direct extension group as the disease process is due to biliary stasis plus infection with inflammation extending through the biliary tract or pyelephlebitis may supervene on cholangitis by extension of infection along the portal spaces via the lymphatics or the small veins of the bile ducts. This usually produces multiple abscesses involving practically the entire liver and closely resembles the classical abscesses which follow appendicitis.

A good example of this type of infection was recently reported by Williams and Ovens[4] in a case of multiple liver abscesses due to Bacillus pyogenes and associated with a gallbladder that was enlarged and firm and contained numerous stones. The

patient was cured with drainage of the gallbladder and cystic duct. The authors point out that the bile ducts can be drained and indirectly also the abscesses higher up by means of cystic or common duct drainage.

Non-penetrating injuries may cause abscess formation in the liver by hematoma formation with destruction of liver tissue. Penetrating injuries may result in destruction of tissue and infection of the liver.

Direct extension as from a ruptured peptic ulcer is a not uncommon cause of solitary liver abscess.

According to Rothenberg and Linder[3] the right lobe is involved five times more frequently than the left lobe. Serege and others as quoted by Eliason and co-workers[2] have shown experimentally that blood flows in the portal vein in two currents, the one on the right from the superior mesenteric vessels passes into the right lobe and the current on the left from the inferior mesenteric and splenic veins passes into the left lobe on the liver. Although Serege has been quoted by several writers on the subject, Eliason and co-workers[2] point out their series of fifteen cases do not confirm this. In twelve of their cases of solitary abscess of known cause and location, three left lobe abscesses arose from foci drained by the superior mesenteric vein and the three foci in the inferior mesenteric drainage led to right lobe abscesses. Of the fifteen solitary abscesses in their series, seven were located on the dome of the right lobe, four on the dome of the left lobe, one on the posterior aspect of the right lobe, one on the posterior aspect of the left lobe, one on the anterior aspect on the right lobe and the location of one was not stated. Two of the cases in this report occurred on the dome of the right lobe and the third involved the left lobe. The solitary pyogenic liver abscess is generally well walled off and when present on the dome of the liver there is usually a reaction of the diaphragm with resulting adhesions and pleurisy with or without effusion. The abscess may at times rupture into the pleural cavity or into the lung itself provided the local reaction has been severe enough to form numerous adhesions of the parietal to the visceral pleura. In the first and second cases in this report there were numerous fine adhesions between the dome of the liver and the diaphragm. The second of the two cases developed a large pleural effusion following surgery.

Signs and Symptoms. Chills, fever, rapid loss of weight and strength, nausea and vomiting, and pain in the hepatic region just below the costal margin are the usual symptoms. In Rothenberg and Linder's[3] experience abdominal pain or symptoms referable to an intra-abdominal lesion were present in only a few of their patients. This was also noted in the second case in this series as the patient's abdominal symptoms were not marked, and were characterized by a catching pain under the right rib margin anteriorly at the onset of the illness which disappeared after a short time. The first and third cases in this report were characterized by rather severe abdominal pain, high fever and loss of strength; and in the first by pain in the right costovertebral angle. Chills with high fever were present in the first two cases. Pain in the lower right thoracic region is frequently the first symptom to draw attention to a disease process in the liver. This symptom was present in the second of the two cases reported in this paper but was never of marked prominence. Jaundice appeared late in the second case, a point noted by Ochsner and Debakey.[1] A septic type of temperature is commonly found and most patients have chills with profuse sweating. This was noted in two cases in this report. Two-thirds of Rothenberg and Linder's[3] series had chills. Various authors on the subject of pyogenic liver abscess give a higher incidence of chills probably due to the fact that most reports, as has been mentioned previously, contain both multiple and solitary pyogenic abscess and the former type generally gives a more septic course with chills and picket fence temperature curve. It is interesting to note that in Ochsner and Debakey's[1]

series of both types of pyogenic abscesses, the incidence of chills was only 36.1 per cent.

Pain in the shoulder on inspiration is not uncommon due to the pleural reaction and was exhibited by Case II in this report. St. John, Pulaski and Fener[5] in their case of solitary pyogenic abscess of the liver caused by an anaerobic nonhemolytic streptococcus noted the production of pain in the right shoulder with deep inspiration with the patient supine and the absence of the pain when the patient was in the sitting position. Tenderness just below the costal margin on the right is frequently present. Localized intercostal pain was not exhibited in these two cases.

Pulmonary signs are frequent as pointed out by Rothenberg and Linder.[3] Case II had dullness at the right lung base with diminished expansion of the right chest and rales probably due to compression of the lung by the liver and he was admitted to the hospital with a diagnosis of pneumonia. This case also developed a right pleural effusion late in the course of the disease. Case III had *x*-ray findings of diaphragmatic pleural irritation with slight effusion. The diagnosis of pneumonia with treatment for this condition is not uncommon before the real nature of the disease process is discovered.

In Case I the white blood count was 25,000 with 88 per cent polymorphonuclears, in Case II the white blood count was 11,400 with 74 per cent segments on admission and rose to 18,000 with 89 per cent segments just before surgery eleven days after admission and in Case III the white blood count was 17,000 with 80 per cent neutrophiles.

The laboratory findings are those of a suppurative process in the body with leukocytosis and not infrequently albumin in the urine. The leukocytosis is as a rule not as high as that found in multiple abscesses but is higher than an uncomplicated amebic abscess.

The spleen is at times palpable as was the case in the second in this report. The liver is often not palpable and the extent of liver enlargement upward is often difficult to determine on physical examination. In Rothenberg's and Linder's[3] series 74 per cent had palpable livers. In neither of the first two cases reported in this paper was the liver palpable and in the third a questionable mass was present which later proved to be the left lobe of the liver.

The *x*-ray findings are important and reveal an elevated diaphragm on the right. Fluoroscopy usually reveals a partially immobile diaphragm with limited excursions. In Rothenberg's and Linder's series one third of the cases showed an elevated and fixed diaphragm. Gessner[6] pointed out that 72 per cent of a series of ninety-six cases of amebic abscess of the liver showed a high right leaf of the diaphragm. In Ochsner's and Debakey's[1] series of forty-seven cases of both types of pyogenic abscess of the liver, the *x*-ray diagnosis was positive in 82.1 per cent. The case reported by St. John and co-workers[5] showed only diminished mobility of the right diaphragm on fluoroscopy and no enlargement of the liver on *x*-ray. Eliason, Brown and Anderson[2] in their series of both types of pyogenic liver abscess obtained only 64 per cent positive *x*-ray findings. All three cases in this report showed elevation of the right diaphragm with limited excursion on fluoroscopy.

Diagnosis. The onset of solitary liver abscess is often insidious and the source is frequently impossible to determine in contrast to multiple liver abscesses in which the onset is usually sudden and acute and the source of infection is more likely to be obvious. The history of chills, fever, vague pain in the hepatic region at times associated with pain in the right shoulder, elevated leukocyte count, *x*-ray and fluoroscopic findings of an elevated right diaphragm with enlarged liver shadow and diminished movement of the diaphragm should make one suspect liver abscess of the solitary variety.

Rothenberg and Linder[3] have shown that nausea and vomiting is an important aid in diagnosis as these symptoms are infrequent in solitary liver abscess whereas in

cholecystitis, pancreatitis, intestinal obstruction, ruptured ulcer and other conditions accompanied by peritoneal irritation, nausea and vomiting are often marked. In the presence of multiple liver abscesses the temperature is higher and more of a septic type of fever with chills being more frequent. Palpable liver enlargement and jaundice are more frequent in multiple liver abscesses.

The onset of amebic liver abscess is insidious and the fever is not as a rule high unless secondary infection has taken place. Aynesworth[7] reported three cases of amebic liver abscess of twelve, nine, and five years durations with low grade fever during this time and a history of chronic invalidism. The patient with an amebic abscess is not as sick as the patient with a pyogenic abscess. The history of diarrhea and the finding of the endameba histolytica in the stools will aid in the diagnosis of amebic abscess.

Subphrenic abscess is more likely to have antecedent infection such as a ruptured appendix. The pain of a subphrenic abscess is often more severe than that in a liver abscess, the liver is not enlarged and costovertebral tenderness is more likely to be present in this condition. Fluoroscopy is likely to reveal more fixation of the diaphragm than in the case of the liver abscess.

Ochsner and Debakey[1] advise against exploratory aspiration of the liver for pus and state that it is a dangerous and unjustifiable procedure. Herrick, quoted by Gessner,[6] with a considerable experience in the Canal Zone with amebic abscess of the liver describes localization by needle as unreliable and speaks of fatalities reported from its use.

Prognosis. The prognosis in solitary pyogenic liver abscess depends on the presence or absence of complications, general condition of the patient, the type of treatment with regard to drainage and the location of the abscess.

In Ochsner's and Debakey's[1] series their mortality in the solitary liver abscesses was 37.5 per cent, Eliason and co-workers[2] reported a mortality of 60 per cent in ten cases of solitary pyogenic liver abscess operated, and Rothenberg and Linder[3] obtained recoveries in 58.3 per cent of all their cases of solitary pyogenic liver abscess.

Cases I, II and III in this report recovered.

Complications. The most frequent complication of solitary pyogenic liver abscess is involvement of the pleura or lungs. The most common site of the solitary abscess is on the dome of the right lobe of the liver, hence the diaphragm on the right early becomes involved as the abscess cavity pushes upward. Adhesions develop soon and pleurisy with effusion, empyema, or rupture into the lung itself have been reported. Cases I and II in this report had adhesions between the diaphragm and the right lobe of the liver and the second case had a large pleural effusion. The third case exhibited *x*-ray findings of diaphragmatic pleurisy with effusion in the costophrenic angles.

Peritonitis as a complication usually results from spilling of pus into the peritoneal cavity while performing transperitoneal drainage.

Treatment. The treatment of pyogenic liver abscess is incision and drainage through a transpleural or transabdominal approach. The transpleural method was first suggested by Trendelenburg in 1883, according to Ochsner and Debakey[1] and later modified into a two stage procedure by Beck. These authors divide the operative procedures into transthoracic and transabdominal either through a transserous or an extraserous approach. In their series nine cases with transpleural drainage had a mortality of 66.6 per cent, and with the extraserous retroperitoneal approach of Ochsner and Nather in six cases there was a mortality of 33.3 per cent. In twenty-two cases in which the transperitoneal method was used the mortality was 72.7 per cent.

In performing the transabdominal approach it is important to carry out the operation in stages so as to allow adequate formation of adhesion before opening the abscess. After making the incision,

which is adequate with a paracostal incision, the wound should be packed with vaseline gauze and the wound reopened several days later and the abscess then drained, provided there are adequate adhesions. Ochsner and Debakey[1] point out that the method of Clairmont for drainage of subphrenic abscess may be used. This consists of a paracostal incision and incision down to the parietal peritoneum and then mobilization of the parietal peritoneum from the lower surface of the diaphragm up to the abscess.

In the first of the author's case, the abscess was in the mid-portion of the dome of the right lobe and was approached through the abdomen using a paracostal incision. Drains were placed in the wound in an attempt to form adhesions and wall off the disease process.

In the second case while waiting for adequate adhesions to wall off the disease process, penicillin was given intramuscularly and also injected into the abscess following aspiration. Subsequent surgery several days later revealed the abscess cavity to contain only a few cc. of bloody serous fluid.

In the third case the abscess in the left lobe of the liver was already walled off by adhesions at the time of surgery.

Therefore, it would seem that penicillin is a potent weapon against the solitary liver abscess when due to the staphylococcus or streptococcus. When operated by either the transpleural or transabdominal approach, penicillin injected into the cavity of the abscess plus systemic use may sterilize the abscess and lessen the dangers of contamination provided a second stage procedure is to be carried out. The technique of Noth and Hirshfeld[8] may prove to be of value in pyogenic liver abscess. These authors treated a case of amebic abscess of the liver by inserting penicillin into the cavity daily. This procedure might be carried out through a transpleural or transabdominal approach while waiting for adhesions to form. This method might make a second stage unnecessary or if the second stage is needed, the abscess may be sterile as was evidently the case in our second patient. Aspiration and injection of penicillin into such abscesses may prove to be a more satisfactory method of treatment in the future by eliminating the extensive sloughing of liver tissue that is seen at times following incision and drainage of a liver abscess.

Another important point is the marked improvement in the general condition of Case II following the second stage at which time the abscess was aspirated and the cavity filled with penicillin. The patient was out of bed four days after the second operation was performed and he was out of bed ambulatory on the second day following the third operation, at which time the abscess was opened.

SUMMARY

1. Three cases of solitary pyogenic abscess of the liver are presented.

2. A brief discussion of solitary pyogenic liver abscess is given.

3. Penicillin is a potent weapon in the treatment of the solitary pyogenic liver abscess especially when adequate drainage is carried out.

4. Aspiration of solitary pyogenic abscess of the liver and injection of penicillin may prove to be a satisfactory method of therapy.

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CARCINOMA OF THE BREAST FOLLOWING BURN*

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THE direct relationship of burns to cancer of the skin is well recognized and generally accepted. Of the numerous reports of cancer of the skin developing in scars of burns, the largest single series of cases has been reported by Treves and Pack.[1] Over a twelve-year period they found twenty-one epidermoid carcinomas and seven basal cell carcinomas growing in the site of previous burns. These cases constituted 1.1 per cent of all the carcinomas of the skin seen. It is true that cancer of the skin may arise in scars produced by other causes, but about 33 per cent of all scars giving rise to a carcinoma are produced by burns.[2] Schrek[3] reported five basal cell carcinomas and seven epidermoid carcinomas developing from scars of different origins (roentgen ray burns, burns, lacerations, surgical operations and ulcerations). They constituted 2.8 per cent of his total number of cases. But of sixty which developed on the scalp, trunk, arms and legs, eleven (or 18 per cent) developed in scars. It is evident from these figures that the proportion of carcinomas of the skin arising from scars is twenty-five times greater on the scalp, trunk and extremities than on the face and neck, where carcinomas from other causes are more common. On the extremities alone, carcinomas developing in the scars of burns make up between 9 per cent and 25 per cent of all cases of carcinoma.[2] Consequently it may be concluded that the appearance of carcinoma in an area where carcinoma is rarely encountered is not purely fortuitous but is certainly related to pre-existing changes induced by heat or some other agent.

As a general rule it takes a long time for a carcinoma to develop in a burn scar. Treves and Pack[1] reported an average interval of 32.5 years, and Pack and Livingston[4] found an average interval of 19 years. There is frequently a history of delayed healing, recurrent setbacks and ulceration. Pack and Livingston recorded an average of 800 days from the time of the burn to complete healing. The cases had been permitted to granulate and skin grafting was not employed. The systematic grafting of burns should diminish the number of these lesions which degenerate into carcinoma.[1,4] Treves and Pack[1] reported six cases of so-called acute burn-scar cancer which developed within several weeks to a few months following the burn and before the skin had completely healed. This type of carcinoma usually appears in older people with atrophic, keratotic skin. Such preparatory skin changes apparently increase the susceptibility of the skin to develop carcinoma following even a superficial burn.[5] On the other hand, in the chronic burn-scar carcinoma in which there is a long interval following the burn before the appearance of neoplasia, the age of the patient is of no importance; it is rather the age of the scar which is of importance in the development of carcinoma.[1,3,6,7]

The cancers developing in a scar have a rather slow rate of growth and usually metastasize late. Histologically, these lesions show the same characteristics of other skin carcinomas but have an extremely dense, fibrotic stroma. When the tumor invades the normal skin, it seems to parallel if not surpass the rate of development of ordinary carcinomas of the skin,[1,6,7] and distant metastases are often present.

Radiotherapy is seldom successful in the treatment of carcinomas arising from scars, because the scarred tissues will not stand the quantity of radiation required for the sterilization of the tumor. Attempts to

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treat these lesions by radiotherapy result in wide areas of necrosis.[1,2,4,6,10] The recommended form of treatment is radical surgical excision and skin graft, followed by regional lymph node dissection when indicated.[11]

The development of carcinoma following thermal injury has not been reported in organs other than the skin and connective tissue. A case of transition of a pigmented nevus into a malignant melanoma following a burn,[1] and another of neurogenic sacroma in a burn scar in a patient with generalized neurofibromatosis, have been cited. There have also been two cases of fibrosarcoma appearing in old burn scars.[12,13] To our knowledge, there have been no cases of tumor arising from muscle, fat or bone within the area of a deep thermic burn.

The two cases presented here represent adenocarcinomas of the breast in which an etiologic relationship to a previous burn is strongly suspected. Admittedly, this suspicion could be mere coincidence, but one must bear in mind that the breast is, of all glandular structures close to the skin, the most susceptible to the development of carcinomas. This report may help to bring to light other such cases which may not have been published because of the belief that this was indeed mere coincidence.

CASE REPORTS

Case I. A. S., E.F.S.C.H. No. 43-5107. A thirty-six-year old white woman entered the hospital in March, 1943, complaining of a mass in the left breast. Seven years before, the breast had been burned by exposure to steam. This was followed by intermittent healing and recurrent ulceration, but the treatment did not include skin grafting. Two years before admission, a mass developed beneath the ulcerated area, and from that time on there had been persistent ulceration with increase in the size of both the ulceration and the tumor mass. In addition, there had been a weight loss of twenty-five pounds during the past year.

On examination, the patient was a red haired, well developed, well nourished, white woman showing evidence of weight loss. There was a large mass in the left breast directly underlying an 8 cm. necrotic ulceration, with obvious skin retraction and edema about the ulceration. (Fig. 1.) An enlarged, firm, movable node was palpable in the left axilla; but the opposite breast and axilla, and both supraclavicular areas were apparently normal.

Laboratory data revealed only an elevated white blood count of 15,700. Skeletal roentgenograms showed no evidence of osseous metastases, but the roentgenogram of the chest disclosed extensive pulmonary metastases. Biopsy of the ulcer bed showed a moderately well differentiated carcinoma, obviously of duct origin, with associated infection and a variable amount of connective tissue stroma. (Fig. 2.) Palliative radiotherapy was directed to the breast and the patient was discharged. She expired August 1, 1943.

Summary. This case represents a carcinoma of the breast occurring in a young woman, following a severe burn. The clinical course is similar in many respects to that found with carcinoma growing in the scar of a burn. Healing by granulation and recurrent ulceration followed a burn of the breast, and after five years, a mass was observed. At examination two years later, the mass was found directly beneath a necrotic ulceration of the skin. A biopsy revealed adenocarcinoma of the breast. Axillary and pulmonary metastases were present, indicating a rather rapidly progressing disease.

Case II. H. C., E.F.S.C.H. No. 44-6565. A fifty-five-year old white woman entered the hospital on July 14, 1944, with a mass in the right breast. At the age of two, there had been a severe hot-water burn involving this region. The nipple was destroyed at that time and subsequent slough of skin and underlying tissue exposed the ribs. Skin grafting was not undertaken and healing resulted in extensive scar formation. Eight months before admission, a small lump appeared in the right breast and was thought to be scar tissue. However, three months before admission there was reddening of the skin with a burning sensation, and subsequent growth of the mass was accelerated, slowly at first but more rapidly later. Six years before admission, an abdominal hysterectomy and unilateral salpingo-oophorectomy had been

Fig. 1. Case 1. Prominent ulceration of breast with nipple destruction.

Fig. 2. Case 1. Photomicrograph (high power); typical carcinoma with infection.

performed, with the removal of a six-pound tumor of the uterus.

On examination, the patient was an obese, white female who presented an old scar over the mid-portion of the right breast, with absence of the areola and nipple. Directly underlying the area of greatest scarring there was a firm, non-tender mass measuring 8 by 10 cm., attached to the skin but freely movable over the underlying fascia. In the central portion of this mass just beneath the skin, there was a 2.5 cm. area of fluctuation. Palpable lymphadenopathy was not present in either axilla or in the supraclavicular regions.

Laboratory data were within normal limits and a roentgenogram of the chest showed no evidence of pulmonary metastases.

On the fourth hospital day, aspiration biopsy of the fluctuant area of the tumor mass yielded 45 cc. of amber, slightly bloody fluid. No pathologic diagnosis could be made on this specimen. Three days later a radical mastectomy was carried out. The gross specimen consisted of the right breast, pectoral muscles and axillary contents. The attached skin showed scarring and thickening. There was a large tumor mass in the breast measuring 11 cm. in its greatest diameter and extending to a depth of 8 cm. below the skin. In the central portion of this tumor just beneath the skin there was a cystic area measuring 6 by 4 by 3 cm., containing a reddish-brown clot. (Fig. 3.) Sections taken through the tumor showed a rather well differentiated breast carcinoma arising from duct epithelium. (Fig. 4.) The stroma showed a marked fibrosis with areas of chronic inflammation. The remainder of the breast tissue was atrophic. Sections through the skin revealed thickening of the epidermis, a reduction in the number and height of the papillae, and a diminution to absence of skin appendages. (Fig. 5.) A marked fibrosis of the subcutaneous tissue extended into the breast parenchyma as well. There was no evidence of carcinoma in the axillary nodes.

The postoperative course was uneventful, and the patient was discharged on August 7, 1944. At the last clinic visit, sixteen months after discharge, there was no evidence of local recurrence or spread of the disease.

Summary. At the age of two, this patient suffered a severe burn of the region of the right breast which destroyed the nipple and surrounding soft tissue of the breast. Healing occurred by scar formation and further ulceration did not develop. Fifty-two years later a mass appeared in this breast directly beneath the area of greatest scarring. A radical mastectomy was performed and examination of the specimen showed a typical adenocarcinoma of the breast growing in a fibrotic parenchyma.

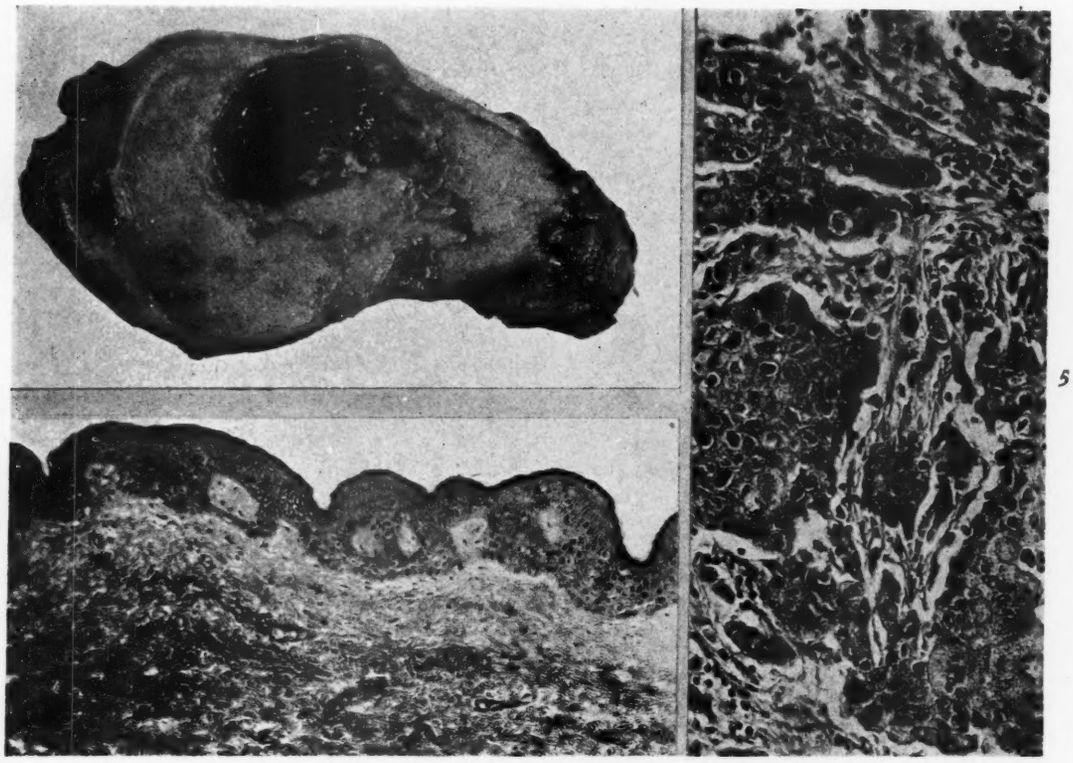

FIG. 3. Case II. Transection of surgical specimen showing large cystic carcinoma.
FIG. 4. Case II. Photomicrograph (high power); typical carcinoma.
FIG. 5. Case II. Photomicrograph (low power); skin in the area of the scar. Note atrophy, fibrosis and absence of skin appendages.

The carcinoma extended deeply into the breast but did not invade pectoral muscles. There was fibrosis in the normal breast parenchyma as well as in the areas of neoplasia.

COMMENT

The sequence of events in both of these cases of breast cancer had a similar pattern. A severe burn, untreated by skin grafting was followed by extensive scarring in both and by chronic ulceration in one. After a long time interval, carcinoma developed in the areas of greatest alteration of the breast. While it cannot be proven that the development of cancer was not a mere coincidence, the sequence of events strongly suggests that there was some etiologic relationship between the development of carcinoma and the earlier burn.

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TUBERCULOUS SALPINGITIS

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SINCE the publication of Hegar's work in 1886, genital tuberculosis and its protean manifestations have stimulated the interest of gynecologists throughout the world. It was unusual to have a Clinical Congress of Surgery in Paris or Berlin during the early twentieth century without frequent references to this infection, its pathogenesis, probable mode of entry and treatment.

ETIOLOGY

The etiology of genital tuberculosis, whether primary or secondary and its relationship to tuberculous involvement of the peritoneum are matters which still remain in high dispute among pathologists and clinicians. It is generally regarded probable that tuberculosis of the internal generative organs is secondary to an infection of similar etiology elsewhere in the body, the lungs being the commonest source. Only in those very unusual cases limited to the vagina, cervix or vulva is it conceivable that the process may be a primary one from direct contact with contaminated instruments or from intercourse with an individual having a discharging tuberculous lesion of the genitourinary tract. For practical purposes, genital tuberculosis is a disease of the internal reproductive apparatus, and the Fallopian tubes are involved in almost every instance, (although tubercles may be grossly absent), hence a discussion of genital tuberculosis connotes a condition of tuberculous salpingitis. Other pelvic organs are slightly less immune; the uterus is involved in about 65 per cent; the ovaries in about 30 per cent, and the cervix in about 5 per cent of all cases. This decreasing frequency is in contrast with the tissue response to an acute gonorrheal infection in which the urethra, Bartholin's glands and vagina show early pathologic change, followed by late secondary salpingo-ophoritis.

In a patient with chronic gonorrheal salpingitis and no history of early characteristic symptoms, the differentiation from pelvic tuberculosis may be quite difficult in the absence of a primary tuberculous focus (lungs-bones).

The relationship of specific tuberculous peritonitis to tuberculous salpingitis clouds the clinical picture further because the occurrence is almost reciprocal, i.e., the peritoneum is involved in more than half of the cases of genital tuberculosis, while in a group composed of patients with primary diffuse peritoneal granulomas, the Fallopian tubes were infected in 44 per cent. When both tubes and peritoneum are diseased there may be no way, even at operation definitely to separate the primary from the secondary process.

Tuberculous salpingitis is seen most often among young adults between the ages of eighteen and thirty-five although its occurrence in infants and in women past the menopause has been occasionally observed. In the French literature the designation of "ascite des jeunes filles" indicates the frequency of this infection during adolescence.

Pathologic changes stimulated by the tubercle bacillus may develope either in the endosalpynx or on the peritoneal covering of the tube. In the first type, the infection is a true salpingitis starting in the mucous membrane of the ampulla and spreading by continuity throughout the deep layers of the tube. The peritoneum itself may show no evidence of involvement. Pyosalpynx, sterility and tuberculous uterine endometritis are very common. In the second type, both tubes

show the evidences of a diffuse tuberculous peritonitis which almost invariably infects the pelvic serosa together with that of the small and large intestine. The gross appearance at laparotomy is that of multiple, widely disseminated tubercles studding the visceral peritoneal surfaces. The process may be predominantly ascitic; or fibroblastic with extensive, dense adhesions between contiguous organs; or caseous with necrosis, ulceration, internal sinus formation and a severe systemic toxemia.

SYMPTOMS

The symptoms of pelvic tuberculosis are often quite bizarre. If the bacillary virulence is great and the host's resistance low, there will result a rapid overwhelming toxemia. This is augmented by secondary pyogenic invasion of the multiple fistulas which develop between involved abdominal contents and the vagina, rectum, bladder and skin. The prognosis in such a patient is unfavorable, and it is mainly this group which accounts for the 20 per cent mortality associated with the disease. Less severe infections may resemble malaria with recurring moderate fever, lassitude, anorexia and a remarkably complete absence of noteworthy abdominal or pelvic complaints.

Salpingitis in a young virgin should be considered tuberculous unless definitely ascribable to a different cause. Menstrual irregularities varying from profuse menorrhagia to amenorrhoea with or without intermenstrual spotting may occur. Dysmenorrhoea is very common. A pelvic infection recalcitrant to adequate treatment probably is tuberculous in origin especially if no evidence of gonorrhea can be found. Many etiologically enigmatic cases of sterility will be found to harbor a bilateral tuberculous process in the endosalpynx, with cicatricial obliteration of both tubal lumina.

DIAGNOSIS

The correct diagnosis can easily be made preoperatively in some patients; it may be impossible even at laparotomy in others. A history of chronic menstrual irregularities in a barren woman with uterine hypoplasia, bilateral adnexal masses and a pulmonary tuberculous focus is highly suggestive. Conversely, salpingectomy is frequently performed for nodular chronically infected tubes with no suspicion that a specific granuloma exists and the microscopic sections furnish the initial and perhaps only clue to its actual tuberculous etiology. In a large university series a correct preoperative diagnosis was made in 13 per cent of an unselected group composed of various pelvic inflammatory diseases. An accurate history together with a meticulous physical examination, evaluating both negative and positive findings is essential if a high degree of correct preoperative diagnoses is desired.

TREATMENT

The treatment will depend on the extent and distribution of the tuberculous process. Total removal of all infected tissue, when possible, affords the best chance for complete recovery. Technical difficulties may, however, prevent radical extirpation, particularly in the extensive fibroblastic and caseous types of visceroperitoneal involvement. Because of their predilection to this condition, the Fallopian tubes should, whenever feasible, be isolated and carefully examined in every patient with genital tuberculosis coming to operation. If involved, complete bilateral salpingectomy with cornual excision to remove the interstitial portions of each tube is desirable. Opinion varies somewhat regarding the disposition of ovarian tissue in the younger patient group. The preservation of normal endocrine physiology is certainly important, but I believe less so than the thorough eradication of all tissue showing gross contamination. It will be recalled that ovarian infection is present in only one of every three patients with tuberculous salpingitis. Potential ovarian conservation is therefore

a good mathematical probability, but when evidence of oophoritis exists, they should be removed without compunction. In the case history presented below, the menses were unexpectedly resumed despite what was thought to be a very complete tubo-ovarian resection. Frequent mention has been made in the literature regarding the beneficial effects which attend the laparotomy and the exposure of infected organs to atmospheric oxygen. Just what this procedure may accomplish is illustrated by the following clinical report:

CASE REPORT

On March 25, 1944, a sixteen-year old girl of Polish extraction came to my office with the following history. About two years ago, she became involved in a white slave ring and for six months was forced to engage in extensive commercial prostitution in a Texas border town. In September, 1942, she escaped and returned home. Because of her experiences and the likelihood of having contracted syphilis, the patient reported to the local venereal disease clinic where repeated Kahn tests proved negative. A dark-field examination, however, performed in the southwest, indicated the presence of spirochete pallida. Cervical specimens failed to demonstrate gonococci, but trichomonas vaginalis infestion was profusely evident in each smear. A course of bismuth and mapharsen was administered under very competent supervision at the clinic. After about four months, the patient failed to return for treatment, stating that she was under the care of a private physician. During this period and for the ensuing six months she enjoyed excellent health; had no systemic complaints, and worked regularly as an apprentice model in a large St. Louis department store. Menses were normal and painless.

On July 4, 1943, while returning from an Independence Day celebration, she experienced a sudden profuse metrorrhagia which lasted about five hours. The cessation of bleeding was succeeded by a fever of 103°F. and slight nausea but no vomiting or abdominal pain. A physcian was called who advised immediate hospitalization, and on July 12th a midline laparotomy was performed under procaine spinal anesthesia. Tentative diagnosis was acute appendicitis. On opening the peritoneum literally hundreds of miliary tubercles were visible on the exposed intestinal surfaces. Extensive caseation with organized fibrinous exudate was present throughout the peritoneal cavity. The gross appearance seemed so hopeless that no detailed pelvic examination was performed. The incision was closed without drainage after insufflation of 100 per cent oxygen. No organs were removed. The surgeon's impression was advanced tuberculous peritonitis. The patient was discharged from the hospital in two weeks; the prognosis was unfavorable. For about one month she was relatively free of symptoms, following which she became aware of an increasing sense of discomfort in the operative region. Shortly afterward there was a sudden exacerbation of the local pain coinciding with the appearance of a blueish, thin-walled tumefaction in the abdominal incision. This was surgically drained leaving a small discharging sinus. For nine months treatment consisted of frequent probing and dressings with no improvement in the condition, which persisted as a tract discharging moderate quantities of a thin, milky, odorless exudate.

It was at this time that she consulted me. Examination revealed a well developed female appearing to be about twenty years old. Her stated age was sixteen. She was 5 feet 9 inches tall and weighed 142 pounds, blood pressure was 114/68, pulse 86/min. and temperature was 99.6°F. The pupils were regular and reacted actively to light and accommodation. Her teeth were excellent, tonsils small with moderate anterior cervical lymphadenopathy. The heart and great vessels appeared normal on auscultation. The breasts were small, pendulous and symmetrical. An especially detailed examination of the lung fields (in view of the history) revealed no pathologic signs. The liver edge and spleen were not palpable. The rectus musculature was well developed. The previous operation left a broad infraumbilical midline cicatrix which contained a granulomatous discharging papule. A sterile probe introduced here penetrated for its full length into the peritoneal cavity without meeting any obstruction. Deep external abdominal palpation failed to elicit even mild subjective tenderness. Vaginal examination disclosed a clean mucosa and cervix. Bartholin's glands were small and Sanger's "gonorrhoeal macules" were absent. The urethra appeared normal; no

exudate was expressed on stripping the paraurethral glands. Bimanually, the uterus was small, even hypoplastic and rather firmly fixed in midposition. On each side there was a distinctly enlarged tubo-ovarian mass which merged indefinitely into the thickened broad ligament. Compression of these masses produced only slight discomfort.

In view of the intractable nature of the fistula despite competent treatment, I advised reoperation and removal of the tract together with its internal communication if possible. It was my opinion at this time that the generalized tuberculous process previously observed had subsided and that there remained a genital tuberculosis with sinus formation.

The patient was admitted to St. Elizabeth Hospital May 29, 1944. *X*-ray examination of the chest was normal. The sedimentation time was fifty minutes for 18 mm. (Linzenmier) suggesting the absence of an acute process. Temperature on admission was 99°F., red blood cells 4.55 m hemoglobin 75 per cent, white blood cell 8,700, stabs 10, segmenters 64 per cent, lymphocytes 17 per cent and mononuclears 9 per cent. Urinalysis and Kahn test were negative.

On May 30th, under spinal anesthesia, the previous operative scar was excised, removing a block of tissue consisting of skin, fascia, necrotic rectus muscle and sinus tract. On opening the peritoneum there was remarkably little evidence of the extensive pathologic change observed ten months earlier. Aside from several filmy adhesions immediately subjacent to the incision, all positive findings involved the pelvic organs. After severing a broad rectouterine fibrinous band, the fundus and two large tubo-ovarian abscesses were easily delivered. The tract which had been carefully isolated was seen to have three internal connections, one to each of the adnexal masses, and a third to a small subperitoneal lymph gland in the vesicouterine space. The adnexal masses were clamped and excised together with the entire sinus tract and the infected gland. Peritonealization was effected with No. 60 cotton and the incision closed in layers with interrupted sutures of the same material.

The postoperative course was uneventful and the patient left the hospital on June 5th, six days following operation. The incision healed completely by primary union. Regular menstrual periods were established two months later, a most unexpected and welcome phenomenon. The patient, now eighteen, weighs 178 pounds and enjoys excellent health. Microscopic sections were reported by the pathologist as showing, "low grade inflammatory process involving all tissues received. There are giant cells of the Langhans' type, a fairly definite tubercle formation and other characteristics of tuberculosis. Diagnosis: Tuberculosis salpingitis."

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New Instrument

BOX OPERATING TABLE*

A SIMPLE DEVICE FOR INFANTS

ROBERT F. BARBER, M.D.
Director of Surgery, College Surgical Service, Kings County Hospital

AND

WALTER C. LAMB, M.D.
Assistant Resident in Surgery, College Surgical Service, Kings County Hospital

NEW YORK, NEW YORK

IN abdominal operations upon infants the standard operating table has been found unsatisfactory. Designed to accommodate the adult, it is difficult of adaptation to the infant. It makes no allowance for the normally flexed position of the infant knee. It makes restraint of the baby difficult. It does not lend itself with ease to the change from the horizontal to the Trendelenburg position. During the course of the operation it affords no means of keeping the infant warm.

FIG. 1. Box operating table in position on regular operating table.

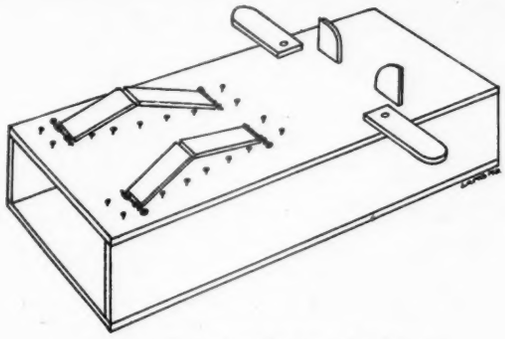

FIG. 2. Exterior design of table.

The author set about to eliminate these drawbacks by designing an operating table for infants.

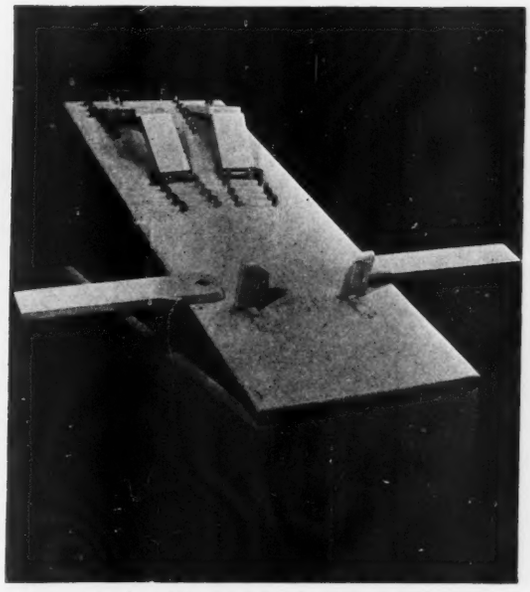

FIG. 3. Table with movable leaf in Trendelenburg position.

The accompanying photographs and diagrams indicate the general construction of the box operating table. It is very simple, consisting of a rectangular wooden box, open at one end, with a top which may be slanted to one of two fixed angles. The box operating table, when placed on top of the regular operating table, can be adjusted to a convenient height for the surgeon when he is operating.

* From the Department of Surgery, Long Island College of Medicine and the College Surgical Service, Kings County Hospital, Brooklyn, New York.

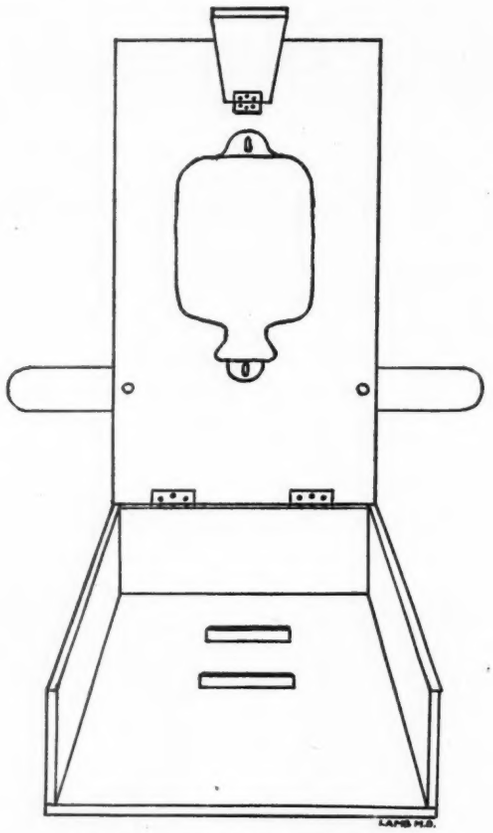

Fig. 4. Interior design of table.

The box operating table is designed to insure not only comfort to the child but also a maximal degree of restraint. It provides arm boards, shoulder rests, leg boards, a heating unit and a means of placing the patient in two different degrees of Trendelenburg. In order to preserve the normal amount of flexion of the child's knees, the leg boards are adjustable at the knees. The straight-leg position may also be had when needed, as for instance, in an inguinal herniotomy. The leg boards may be adjusted in their distance from the shoulder rests so as to accommodate infants of varying lengths. The table is padded with soft material such as cotton or felt. The heating unit consists of a hot water bag which is buttoned to the undersurface of the movable leaf of the table.

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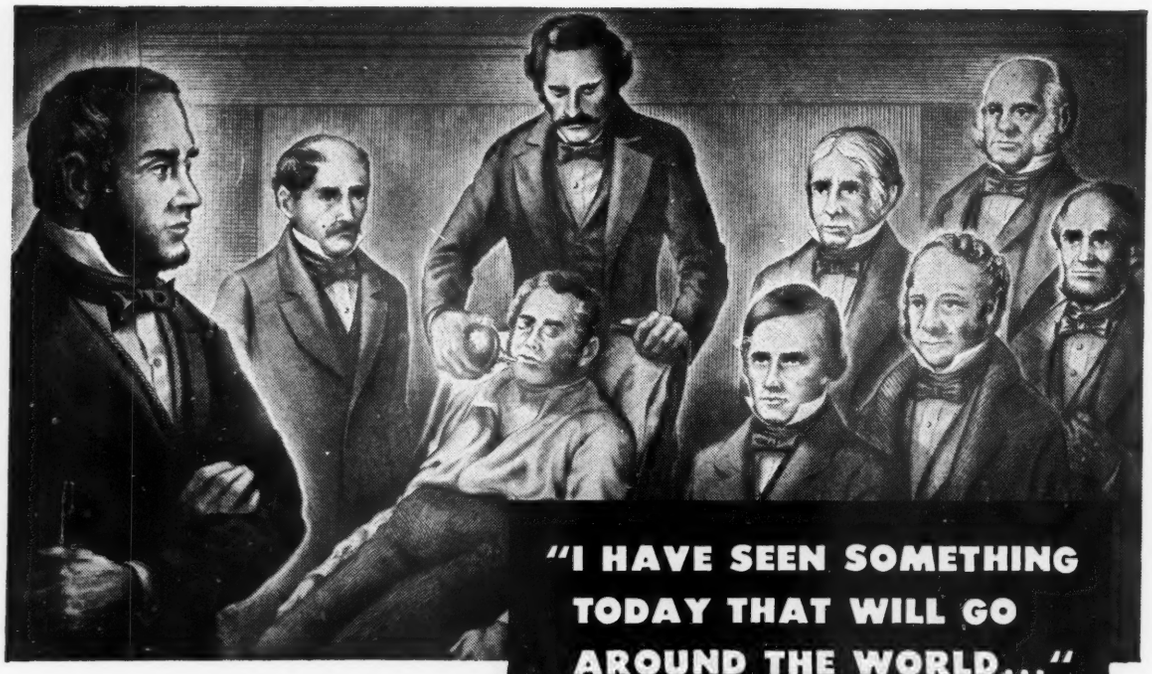

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1 Davison, F. R.: Synopsis of Materia Medica, Toxicology, and Pharmacology, 3rd ed., St. Louis, Mosby, 1944.

2 MacIntosh, R. R., and Pratt-Bannister, F. B.: Essentials of General Anaesthesia, 3rd ed., New York, Oxford University Press, 1943.

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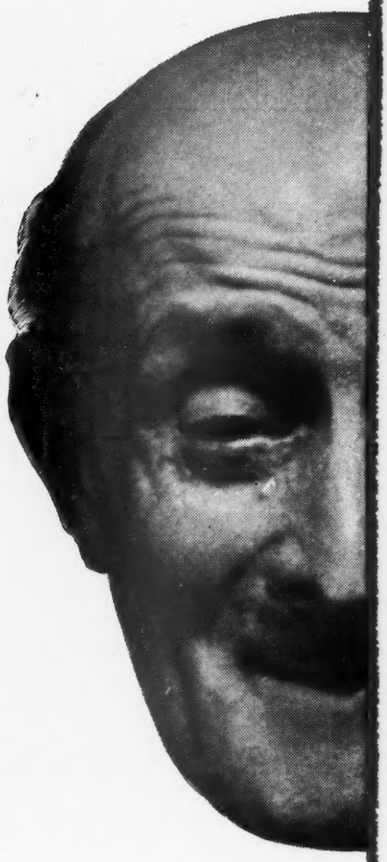

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* Cullen, S. C.: Anesthesiology 5:166 (March) 1944.

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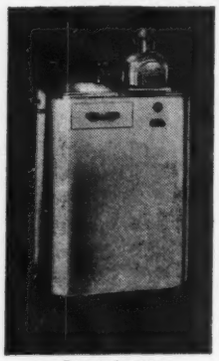

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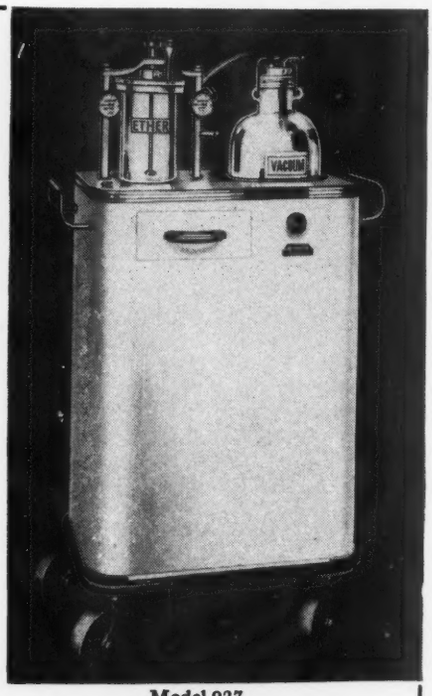

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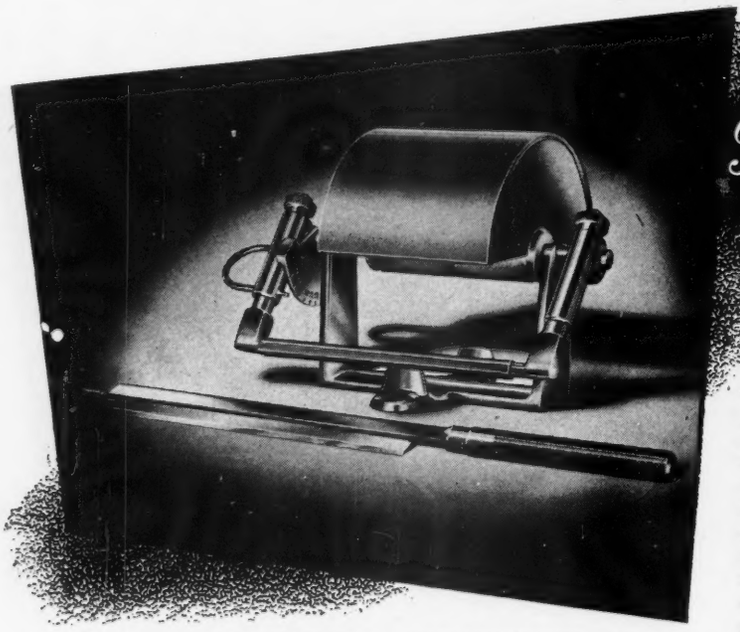

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Announces continuous courses

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New Names for

Iodine Tinctures

Effective April 1, 1947, the following names become official in United States Pharmacopoeia XIII and National Formulary VIII:

1. Iodine Tincture U.S.P. XIII

[Official in U.S.P. XII as Mild Tincture of Iodine]

Formula

Iodine	20 Gm.
Sodium Iodide	24 Gm.
Diluted Alcohol, a sufficient quantity, To make	1000 cc.

•

2. Strong Iodine Tincture N.F. VIII

[Official in U.S.P. XII as Tincture of Iodine]

Formula

Iodine	70 Gm.
Potassium Iodide	50 Gm.
Distilled Water	50 cc.
Alcohol, a sufficient quantity, To make	1000 cc.

It will be noted that there are no changes in either formula and, of course, no change in effectiveness. In addition to its value as an antiseptic and germicide, Iodine continues to serve the profession in many other ways for the prevention, diagnosis, and treatment of disease.

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Calories	**202**	**Phosphorus**	**206 mg.**
Protein	**7.1 Gm.**	**Iron**	**1.6 mg.**
Fat	**5.0 Gm.**	**Vitamin A**	**193 I.U.**
Carbohydrate	**33.0 Gm.**	**Thiamine**	**0.17 mg.**
Calcium	**156 mg.**	**Riboflavin**	**0.24 mg.**
		Niacin	**1.4 mg.**

**Composite average of all breakfast cereals on dry weight basis.*

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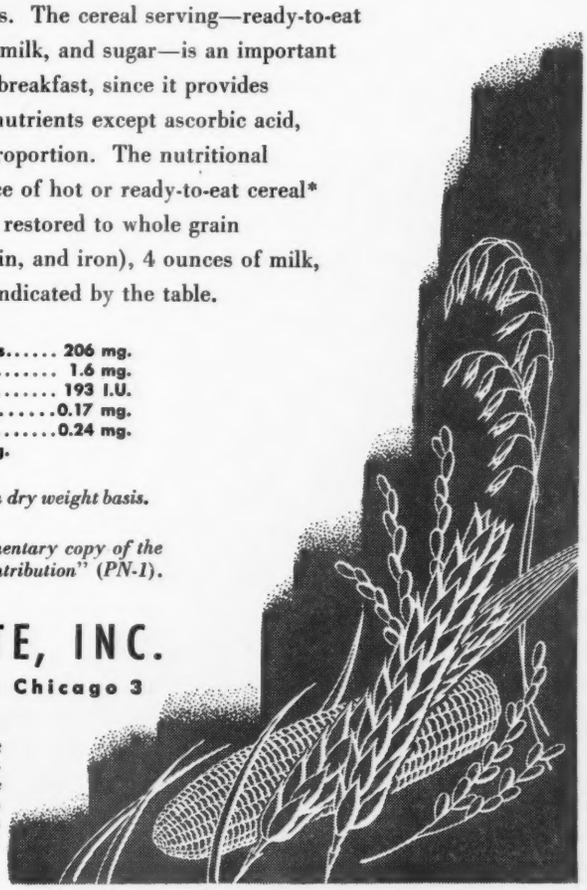
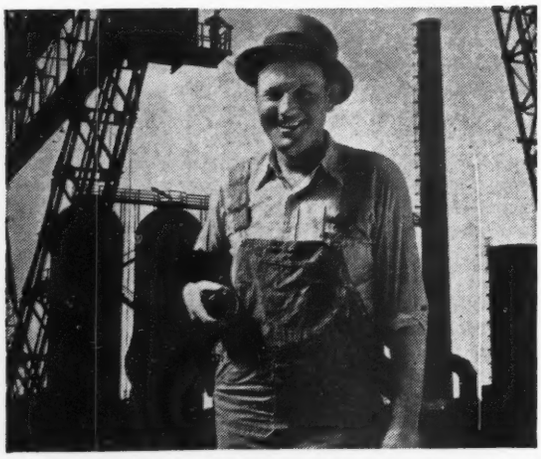


PICTURE QUIZ: Which one of these people gives the right reason for buying U.S. Bonds?

(ANSWER BELOW)

1. **Easy to save!** "I'm putting my money into U.S. Bonds because it's the *easiest way* for me to save a regular amount each week. So far, I've saved $500 without missing the money!"

2. **Plans for the future!** "Ten years from now, the money I'll get for my U.S. Bonds will help to send my kids to college, or buy our family a new home."



3. **Rainy day!** "Maybe a rainy day's coming for me. Maybe it isn't. But I am taking no chances. That's why I'm buying all the U.S. Bonds I can through my Payroll Savings Plan."

THE ANSWER

Every one of these people gives the "right" reason—because there's more than one right reason for buying U.S. Bonds.

Whichever way you buy them—through Payroll Savings, or your local bank or post office—U.S. Bonds are the best investment you can make!

SAVE THE EASY WAY... BUY YOUR BONDS THROUGH PAYROLL SAVINGS

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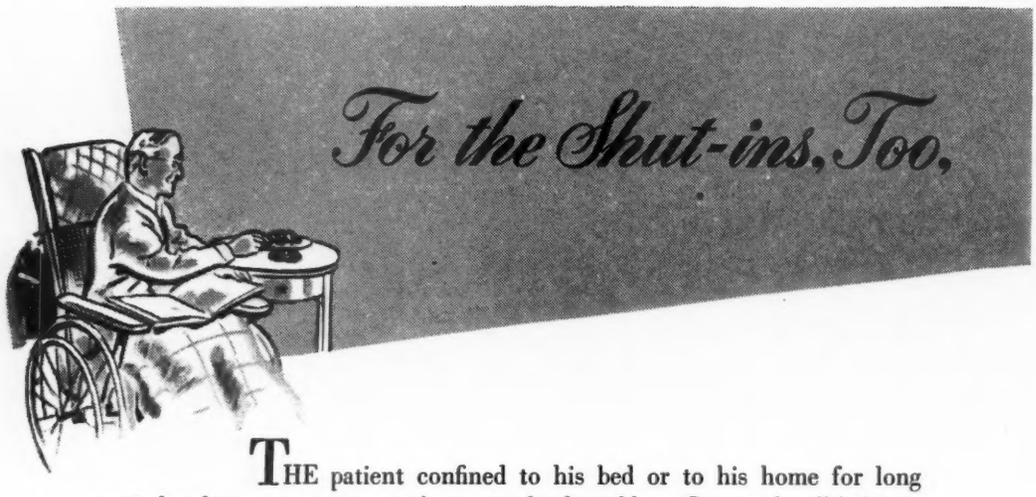

THE patient confined to his bed or to his home for long periods often presents more than a medical problem. Sense of well-being is difficult to achieve or maintain under such circumstances, yet is of high therapeutic importance. Anorexia, engendered by inactivity, makes adequate nutrition in many such instances a serious problem.

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THE NUTRITIONAL PLATFORM OF CANDY

1. Candies in general supply high caloric value in small bulk.
2. Sugar supplied by candy requires little digestive effort to yield available energy.
3. Those candies, in the manufacture of which milk, butter, eggs, fruits, nuts, or peanuts are used, to this extent also—
   (a) provide biologically adequate proteins and fats rich in the unsaturated fatty acids;
   (b) present appreciable amounts of the important minerals calcium, phosphorus, and iron;
   (c) contribute the niacin, and the small amounts of thiamine and riboflavin, contained in these ingredients.
4. Candies are of high satiety value; eaten after meals, they contribute to the sense of satisfaction and well-being a meal should bring; eaten in moderation between meals, they stave off hunger.
5. Candy is more than a mere source of nutriment—it is a morale builder, a contribution to the joy of living.
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1. Batterman, R. C.: Arch. Int. Med. 71:345, 1943.
2. Batterman, R. C.: Connecticut M. J. 8:13, 1944.

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(1) Allen, E., and Baum, H. C.: Am. J. Obst. & Gyn., 45:1, 1943.
(2) Karnaky, K. J.: Texas State J. Med., 39:1, 1943.
(3) Chrisman, R. B. Jr.: J. Tennessee M. A., 35:455, 1942.
(4) Bland, P. B. and Rakoff, A. E.: Med. World, 58:502, 1940.
(5) Siegler, S. L.: Am. J. Obst. & Gyn., 52:1, 1946.

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The American Journal of Surgery

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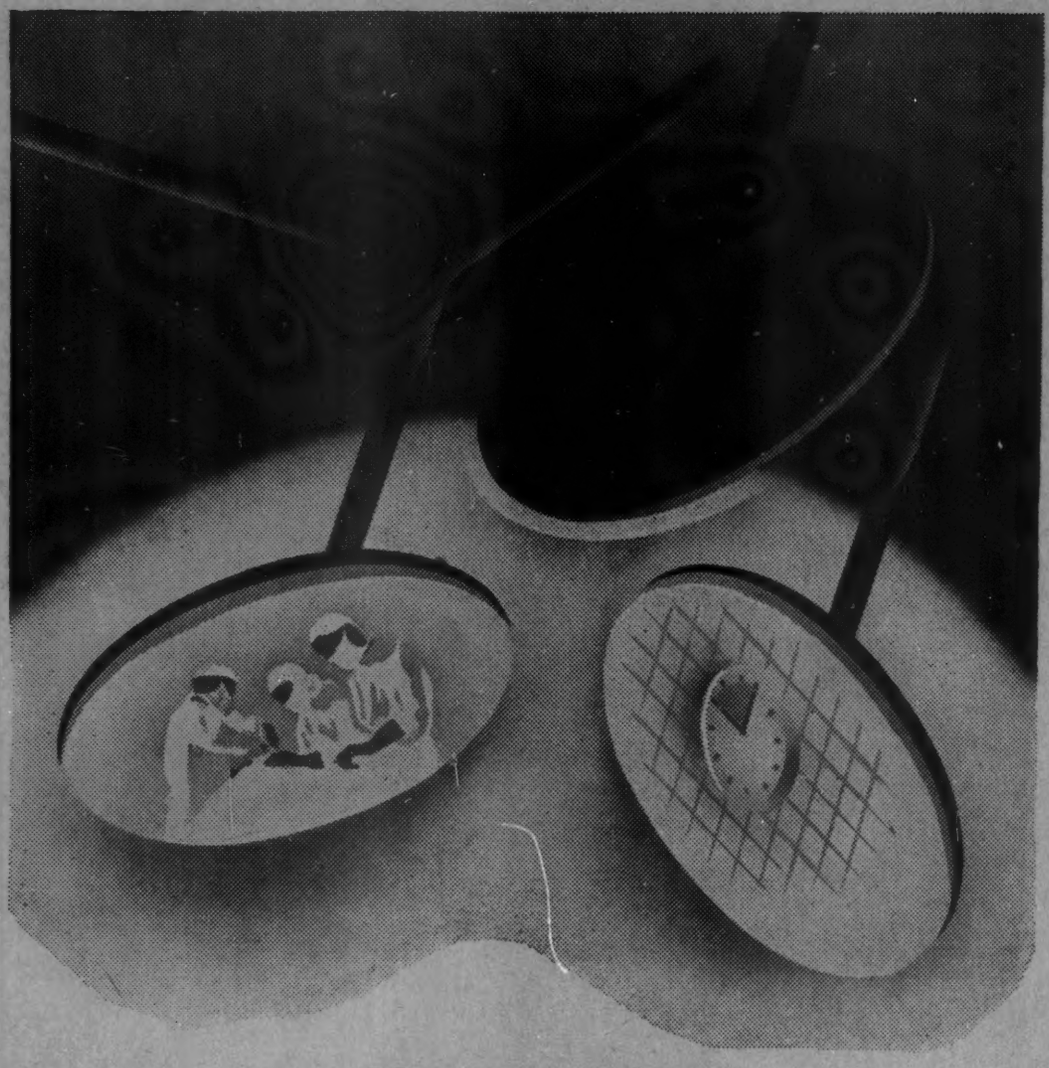

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